RF Development Platform

Designer Reference Manual

M68HC08
Microcontrollers

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RF Development Platform

Designer Reference Manual

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The following revision history table summarizes changes contained in this document. For your convenience, the page number designators have been linked to the appropriate location.

Revision History

Date	Revision Level	Description	Page Number(s)
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Table of Contents

Chapter 1
Introduction and Setup

Chapter 2
Operational Description

Chapter 3
Schematics and Bill of Materials

Chapter 4
Hardware Design Considerations

Chapter 5
Software Design Considerations

Chapter 6 Source Code

Chapter 1
Introduction and Setup

1.1 Introduction

This document describes the features of the RF Development Platform project. It is a learning/development tool for customers that have not used Freescale's RF solutions. It supports Tango3 (MC33493), Romeo2 (MC33591) RF modules and MC908QF4EVB at 315, 434, 868, and 928 MHz. The design supports future RF devices like the MC33695 (Echo). Also, it is possible to add sensor boards to demo complex systems such as RF enabled PIR detectors, smoke alarms, or fire alarms.

This development platform uses Freescale modular MCU boards and Tango3/Romeo2 RF boards to allow the user to 'plug and play' any HC(S)08 MCU and any RF module. It provides Tango3/Romeo2, keypad, LCD, relay, TRIAC, buzzer, LED software drivers, and TEAMAC encryption software in order to reduce development time.

To date, most RF reference designs and tools have been 'hardwired' to a specific task. For example, RK2 RKE demo, or tire pressure monitor demo. This allows the user to get a feel of component count, PCB size, etc., related to a very specific application. However, there are many designers developing a wide variety of applications where the exact requirements vary from application to application.

Therefore, the RF development platform provides a general-purpose platform that allows the user to prototype and demonstrate many different applications. It reuses forthcoming Tango3 and Romeo2 development tools to reduce development time/costs, maintain compatibility with off the shelf development tools, and guarantee good RF performance. It is shipped pre-configured to demonstrate RKE/remote sensing and home connectivity RF networks using the QF4, Tango3, and Romeo2.

The tool set consists of a set of MCU modules that use a common connector layout named '40-pin connector'. All new HC(S)08 MCUs, and many older parts, have an evaluation board supporting this standard. RF modules for Tango, Romeo and Echo were developed to support the same connector standard. A set of software drivers were developed for these modules to allow users to quickly develop application code.

Figure 1-1 shows the RF development platform concept based on Freescale's RF development tools. It reuses all existing tools. Additionally, two new boards have been developed, a 68HC908QF4 board and a general-purpose baseboard.

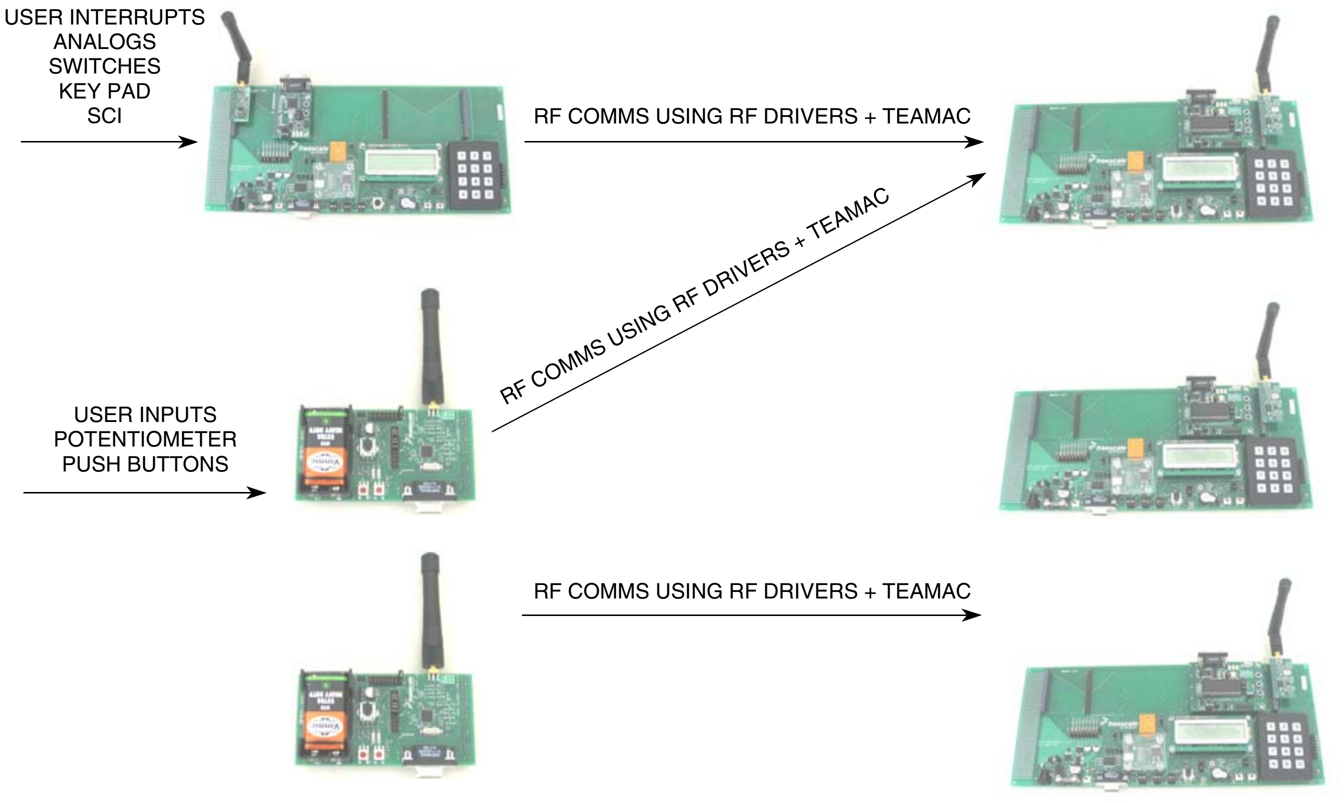

USER INTERRUPTS
ANALOGS
SWITCHES
KEY PAD
SCI
RF COMMS USING RF DRIVERS + TEAMAC
RF COMMS USING RF DRIVERS + TEAMAC
USER INPUTS
POTENTIOMETER
PUSH BUTTONS
RF COMMS USING RF DRIVERS + TEAMAC

Figure 1-1. RF Development Platform

The QF4 board is a small PCB with QF4, some switches, LEDs and an antenna. This allows the QF4 to be used as a transmitter. It will also provide a monitor mode interface for software development and debugging.

The baseboard is a general-purpose interface board that features keypad, LCD display, relay, TRIAC and various other I/O peripherals. It uses the standard I/O connector concept, so MCU modules and RF modules can be plugged into it. Note, this means it can be used in a transmitter, receiver, or transceiver configuration

These two boards in combination with the RF development tools provide a complete hardware platform for developing simple RF networks. RF communications between boards can be achieved using the existing RF software drivers. Additionally, encryption can be added using TEAMAC software routines.

1.2 RFDP Baseboard (Key Features)

The baseboard is a general-purpose interface board compound by a keypad, LCD display, relay, TRIAC and various other I/O peripherals. The features of this development tool are listed below.

- Two female standard 40-pin I/O connectors for RF modules (Tango3, Romeo2, Echo)
- Two male standard 40-pin I/O connectors for MCU demo boards
- One power supply unit for 3-V and 5-V MCU and RF modules
- 12-key keypad
- One 2 x16 character LCD

- Two SPST switches
- One op-amp for sensor signal boosting
- One opto-resistor sensor
- Eight LEDs
- One potentiometer
- One mains relay
- One opto-isolated TRIAC
- One buzzer
- Zero-cross detection circuit
- Serial monitor interface for debug and programming
- Powered with a 7.5 Vac adaptor
- Fuse protected
- Prototyping area

1.3 QF4 (Key Features)

1.3.1 Microcontroller

The MC69HC908QF4 is a high-performance M68HC08 architecture microcontroller with an UHF transmitter module. The main characteristics of the microcontroller are:

- High-performance M68HC08 architecture
- 4-channel, 8-bit analog-to-digital converter (ADC)
- 16-bit, 2-channel timer interface module (TIM)
- 13 general-purpose input/output (I/O) ports
- $\overline{\text{IRQ}}$, $\overline{\text{RST}}$, KBI, COP, and LVI capabilities
- Power saving wait and stop modes
- Trimmable internal oscillator
- Supply voltage: 2.2–3.6 V
- Temperature range: –40 to 128°C

1.3.2 UHF Transmitter Module

The main characteristics of the UHF transmitter module are:

- RF transmitter (UHF)
- 315/434/868/928 MHz operation
- OOK and FSK modulation selectable
- Adjustable output power
- Data clock output for MCU
- Fully integrated VCO
- Low external component count
- Typical application compliant with ETSI standard
- 32-pin plastic low-profile quad flat pack (case number 873A)

1.3.3 MC908QF4EVB

Key features of the MC908QF4EVB are:

- Different frequencies available just by changing the BOM
- With and without power amplifier versions just by changing the BOM
- Low cost PCB (only two layers)
- It can be used as an evaluation board for a wide range of applications

1.4 Demonstration Software

There are two software programs for demonstrating some capabilities and features of the RF development platform, these demo programs are:

1. RKE / Remote Sensing Demo
2. Home Connectivity Demo

1.4.1 Home (Key Features)

The system has at least two transmitters, one using the MC68HC908QF4, the other one using an MC9S08RG60 MCU module with the Tango3 RF module and baseboard. The QF4 transmitter can send simple ‘open/close’ commands that can control the relay and display some text on the LCD. It can also take ‘analog’ input from a potentiometer and send it to a receiver when values need to be updated. The second transmitter can also send ‘open/close’ commands and the value of a key pressed on the keypad. This demo is shown in Figure 1-2.

The receiver has a baseboard with AP64 MCU and Romeo2 boards attached. Messages from transmitters to the receiver are sent using software drivers with the TEAMAC encryption code running on top. This software demo is compounded by two layers, the high and low levels.

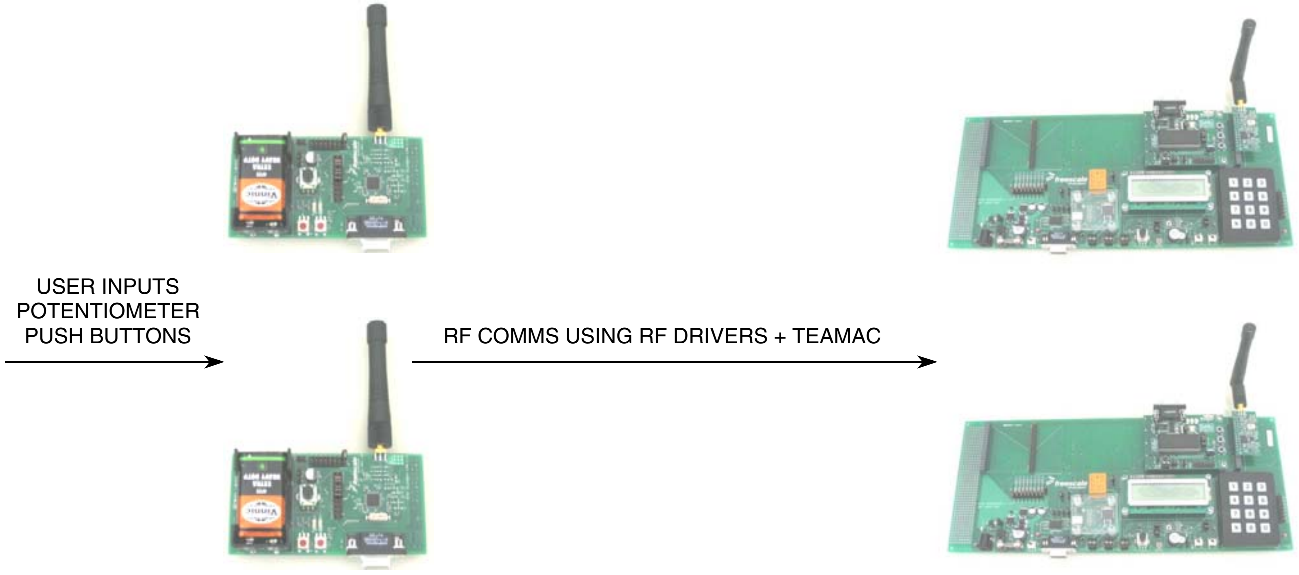


Figure 1-2. Simple System to Show Control of Lamps and other Mains Powered Items

1.4.2 RKE (Key Features)

This setup is similar to RKE/remote sensing demo, except there are now multiple receivers. The QF4 transmitters can send messages to any number of receivers (two shown in Figure 1-3) that can control some mains powered devices.

The system has at least two transmitters using the MC68HC908QF4. The QF4 transmitters can send simple 'open/close' commands that can control the relay and display some text on the LCD; it can also take 'analog' input from a potentiometer and send it to the receiver when values need to be updated.

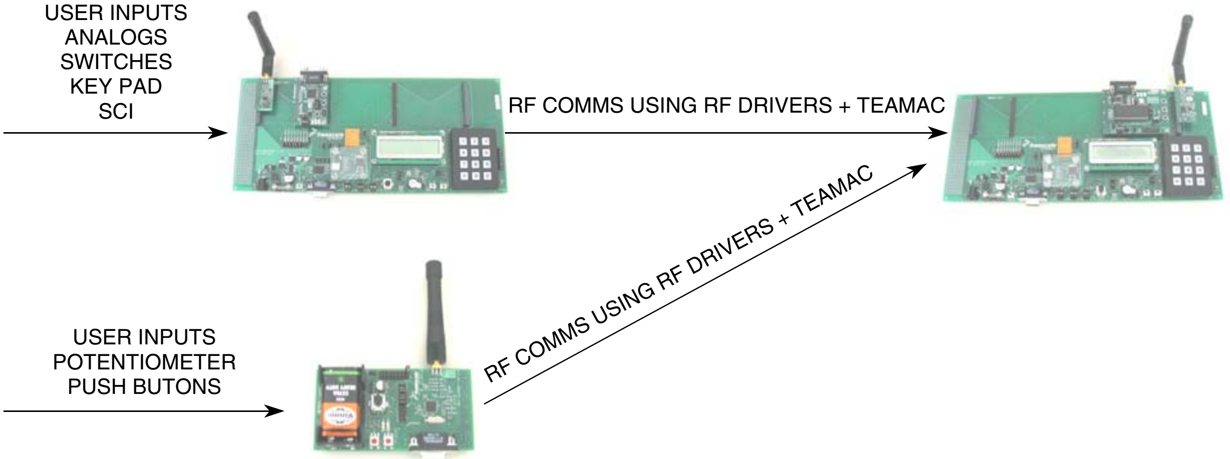


Figure 1-3. RKE / Remote Sensing Demo

The receivers have a baseboard with AP64 MCU and Romeo2 boards attached. Messages from transmitters to the receiver are sent using software drivers with the TEAMAC encryption code running on top. This software demo is compounded by two layers, the high and low levels.

1.5 Applications Overview

The following list provides an overview of the various applications:

- Consumer:
  Garage door opener, garage lights, sound control, TV control, communications sensors
- Automotive:
  Locks, TPS, radio control, RKE
- Industrial:
  Remote sensing

1.6 Setup Guide

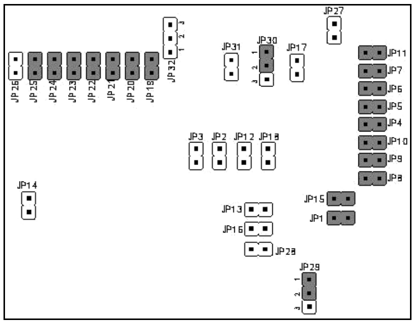
1.6.1 RKE / Remote Sensing Demo

The following steps provide a basic procedure to run the RKE / Remote Sensing Demo with the RF Development Platform.

1. Unpack demo boards:
   - 2 RFDP baseboards
   - 1 DEMO908AP64
   - 1 DEMO9S08RG60
   - 1 Tango3 (MC33493)
   - 1 Romeo2 (MC33591)
   - 1 MC908QF4EVB.
2. Configure the jumpers of the boards.
   - Configuration of the DEMO9S08RG60 board:

     Jumper PWR_SEL:1 must be set and PWR_SEL:2 must not be placed

     Jumpers USER: 1...4 must not be placed
   - Configuration of the baseboard as transmitter:



These jumpers must be set: JP1, JP4, JP5, JP6, JP7, JP8, JP9, JP10, JP11, JP15, JP19, JP20, JP21, JP22, JP23, JP24, and JP25.

The jumper JP30 must be in the 1–2 position.

Note: This figure shows the relative location of the jumpers in the baseboard.

Note: The gray color is “set” and white color is “not placed”.

   - Connect the DEMO9S08RG60 to slot J1.
   - Connect the Tango3 (MC33493) to slot J2.

NOTE

Make sure that pin “1” of the 40-pin connectors in both boards matches with pin “1” of the baseboard and that the switch S3 is in the + 3.3-V position.

   - Configuration of the MC908QF4EVB board:

     Jumper VSEL must be in the 1–2 position, and the ON/OFF jumper must be set.

     Battery of 9 V PP3 must be in the BATTHOLDER

     Jumpers from J3 to J7 and J11 must be set

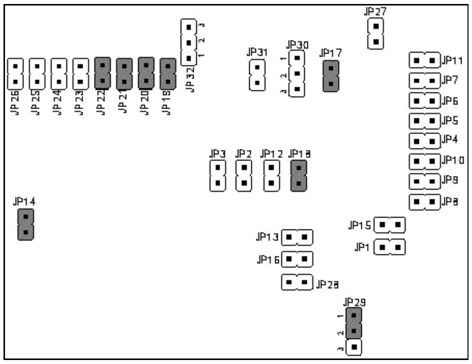
     The other jumpers must not be placed
   - Configuration of the DEMO908AP64 board:

     Jumper PWR_SEL:1 must be set and PWR_SEL:2 must not be placed

     Jumpers OSC_SEL must be in the 2–3 position.

     The other jumpers are don’t cares

– Configuration of the baseboard as receiver:

 JP27 JP32 3 2 1 JP31 JP30 JP17 JP26 JP25 JP24 JP23 JP22 JP21 JP20 JP19 JP11 JP7 JP6 JP5 JP4 JP10 JP9 JP8 JP3 JP2 JP12 JP18 JP14 JP15 JP1 JP13 JP16 JP28 JP29	These jumpers must be set: JP14, JP17, JP18, JP19, JP20, JP21, and JP22. The jumper JP29 must be in the 1-2 position. **Note:** The figure shows the relative location of the jumpers in the baseboard. **Note:** The gray color is “set” and white color is “not placed”.

– Connect the DEMO908AP64 to slot J3.

– Connect the Romeo2 (MC33591) to slot J4.

NOTE

Make sure that pin “1” of the 40-pin connectors in both boards match with pin “1” of the baseboard and that the switch S3 is in the + 5 V position.

3. Connect the antennas to SMA connectors.
4. Connect 9 Vac to both baseboards in the jack J6.
5. The code for the RKE demo is in the demo board CD with the names:
   “RKEdemoRG60Tx” for the DEMO9S08RG60 board
   “RKEdemoAP64Rx” for the DEMO908AP64 board
   “RKEdemoQF4Tx” for the MC908QF4EVB board.

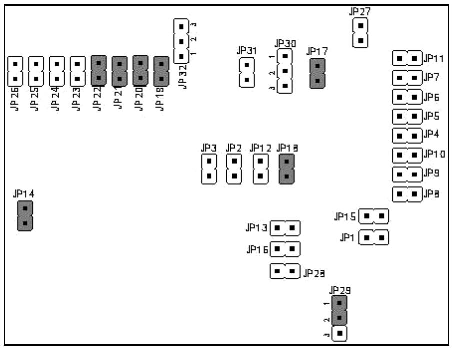
   For more details on how to program the demo boards please refer to the following sections.

1.6.2 Home Connectivity

The following steps provide a basic procedure to run the Home Connectivity Demo with the RF Development Platform. Please refer to the user manual in the Documentation folder of the demo board CD for more detailed information.

1. Unpack demo boards:
   – 2 RFDP baseboards
   – 2 DEMO908AP64
   – 2 Romeo2 (MC33591)
   – 2 MC908QF4EVB.
2. Configure the jumpers of the boards.
   – Configuration of both MC908QF4EVB board:
   Jumper VSEL must be in the 1-2 position and ON/OFF jumper must be set.
   Battery of 9V PP3 must be in BATTHOLDER.
   Jumpers from J3 to J7, and J11 must be set.
   The other jumpers must not be placed.

- Configuration of both DEMO908AP64 board:
  Jumper PWR_SEL:1 must be set and PWR_SEL:2 must not be placed.
  Jumpers OSC_SEL must be in 2-3 position.
  The other jumpers are don't cares.
- Configuration of both baseboard as receiver:



These jumpers must be set: JP14, JP17, JP18, JP19, JP20, JP21, and JP22.

The jumper JP29 must be in the 1–2 position.

Note: The figure shows the relative location of the pins in the baseboard.

Note: The gray color is "set" and white color is "not placed".

3. Connect the DEMO908AP64 to slot J3.
4. Connect the Romeo2 (MC33591) to slot J4.

NOTE

Make sure that pin "1" of the 40-pin connectors in both boards matches with pin "1" of the baseboard and that the switch S3 is in the + 5 V position.

5. Connect the antennas to SMA connectors.
6. Connect 9 Vac to both baseboards in the jack J6.
7. The code of Home Connectivity Demo is in the demo board CD with the names:
   "HomedemoAP64Rx" for the DEMO908AP64 board
   "HomedemoQF4Rx" for the MC908QF4EVB board

   For more details regarding how to program the demo boards please refer to the following sections.

NOTE

In the code of HomedemoAP64Rx you must change the definition of ROMEO_ID_VALUE in the file Romeo.h (61). One board of DEMO908AP64 must be saved with the value 0x10 and the other with 0x20.

8. The lamp connection is shown in Figure 1-4.

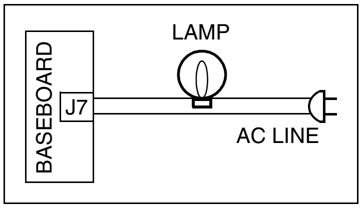


Figure 1-4. Lamp Connection

1.6.3 Downloading Demo Software to MCUs

1.6.3.1 Programming MC68HC908QF4 MCU

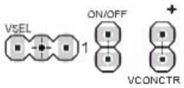
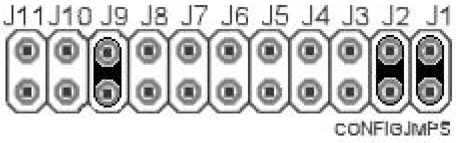
Programming through the serial monitor:

1. Use the MON08 monitor to install the RKEdemoQF4Tx program. The MON08 monitor allows a user to program the MCU Flash and debug application via serial connection.
2. Copy and open the “RKEdemoQF4Tx.zip” file to your PC, and extract the files into a working folder on your desktop.

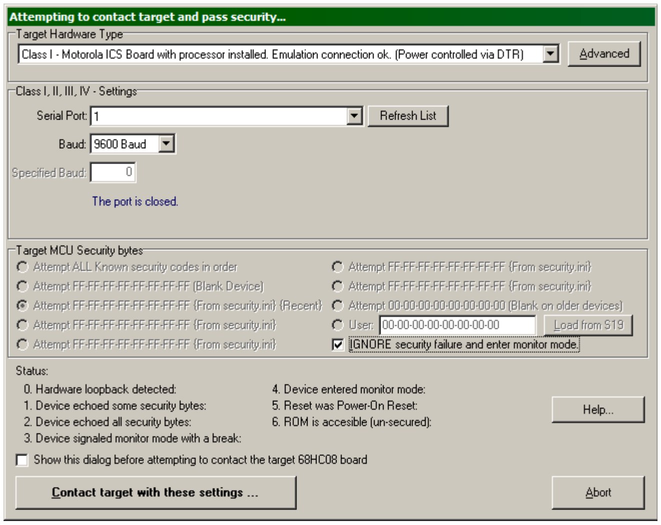
NOTE

Be sure to extract, and not just copy, the files.

3. The next step is to prepare the board by plugging in the 9-V battery or connecting an external 3.3-V source to VCONCTR and selecting the correct jumper position for VSEL. If using a 9-V battery, set the jumper to connect positions 1 and 2 of the VSEL header.

For an external voltage source set the jumper to connect positions 2 and 3 of the VSEL header. The ON/OFF jumper must be placed if using the on-board 9-V battery.	
In the CONFIGJMPS header, the jumpers that should be placed are J1, J2, and J9. Next connect the serial cable from the MC908QF4EVB to a COM port on your computer.	 J11 J10 J9 J8 J7 J6 J5 J4 J3 J2 J1 CONFIGJMPS

4. Now you are ready to open a CodeWarrior project and click on “Debug” under Project in the menu bar, or hit F5. The “Attempting to contact target and pass security…” window should appear. If not, change the debug mode to “In-Circuit Debug/Programming” in the PEDebug menu. Make sure you have the same values for the following options:

	**Target Hardware Type:** Class I **Serial Port:** 1 (Could vary depending on the PC COM port used) **Baud:** 9600 Baud **Target MCU Security Bytes:** “IGNORE security failure and enter monitor mode”.

Attempting to contact target and pass security...

Target Hardware Type

Class I - Motorola ICS Board with processor installed. Emulation connection ok. (Power controlled via DTR) [Advanced]

Class I, II, III, IV - Settings

Serial Port: 1 [Refresh List]

Baud: 9600 Baud

Specified Baud: 0

The port is closed.

Target MCU Security bytes

○ Attempt ALL Known security codes in order
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF (Blank Device)
● Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini} {Recent}
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini}
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini}
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini}
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini}
○ Attempt 00-00-00-00-00-00-00-00 (Blank on older devices)
○ User: 00-00-00-00-00-00-00-00 [Load from S19]
☑ IGNORE security failure and enter monitor mode.

Status:

0. Hardware loopback detected:
1. Device echoed some security bytes:
2. Device echoed all security bytes:
3. Device signaled monitor mode with a break:
4. Device entered monitor mode:
5. Reset was Power-On Reset:
6. ROM is accesible (un-secured):

[Help...]

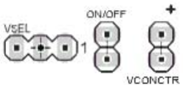
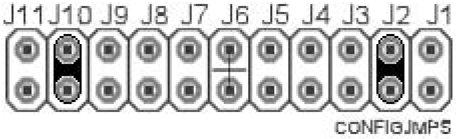
□ Show this dialog before attempting to contact the target 68HC08 board

[Contact target with these settings ...] [Abort]

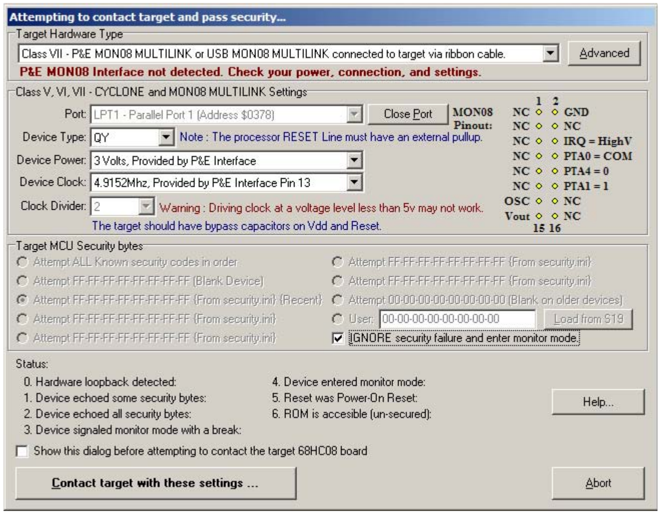
5. Finally click the “Contact target with these settings…” button and if you are asked to “Erase and program flash” click “Yes”. After that the MCU Flash will be programmed.

Programming using the MON08 multilink interface:

1. The next table shows the jumper settings for programming the MC908QF4EVB using the MON08 multilink interface.

It is important to verify that the VSEL and ON/OFF jumpers have been removed, in order to avoid damage to the board or MON08 multilink interface. Power supply for programming will be provided by MON08 multilink. None of the jumpers shown in 1–10 must be set.	
In the CONFIGJMPS header, the jumpers that should be placed are J2 and J10.	

2. Plug the MON08 multilink to the MON08_MULTILINK connector located in the MC908QF4EVB. Please be sure to match the red line of the MON08 multilink interface with the MON08_MULTILINK connector. Apply power to the MON08 multilink interface and connect it to you PC parallel port.
3. Now you are ready to open a CodeWarrior project and click the "Debug" button in the menu bar under the project window, or hit F5. The "Attempting to contact target and pass security…" window should appear. If not, change the debug mode to "In-Circuit Debug/Programming" in the PEDebug menu. Make sure you have the same values for the following options:

	**Target Hardware Type:** Class VII **LPTx:** Parallel Port x (Could vary depending on the PC Parallel port used) **Device Type:** QY **Device Power:** 3 Volts, provided by P&E Interface **Device Clock:** 4.9152 MHz, provided by P&E Interface Pin13 **Clock Divider:** 2 **Target MCU Security Bytes:** "IGNORE security failure and enter monitor mode".

Attempting to contact target and pass security...

Target Hardware Type: Class VII - P&E MON08 MULTILINK or USB MON08 MULTILINK connected to target via ribbon cable. [Advanced]

P&E MON08 Interface not detected. Check your power, connection, and settings.

Class V, VI, VII - CYCLONE and MON08 MULTILINK Settings

Port: LPT1 - Parallel Port 1 (Address $0378) [Close Port]

Device Type: QY — Note : The processor RESET Line must have an external pullup.

Device Power: 3 Volts, Provided by P&E Interface

Device Clock: 4.9152Mhz, Provided by P&E Interface Pin 13

Clock Divider: 2 — Warning : Driving clock at a voltage level less than 5v may not work.

The target should have bypass capacitors on Vdd and Reset.

MON08 Pinout:

1		2
NC		GND
NC		NC
NC		IRQ = HighV
NC		PTA0 = COM
NC		PTA4 = 0
NC		PTA1 = 1
OSC		NC
Vout		NC
15		16

Target MCU Security bytes

○ Attempt ALL Known security codes in order
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF (Blank Device)
● Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini} {Recent}
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini}
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini}
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini}
○ Attempt FF-FF-FF-FF-FF-FF-FF-FF {From security.ini}
○ Attempt 00-00-00-00-00-00-00-00 (Blank on older devices)
○ User: 00-00-00-00-00-00-00-00 [Load from S19]
☑ IGNORE security failure and enter monitor mode.

Status:
0. Hardware loopback detected:
1. Device echoed some security bytes:
2. Device echoed all security bytes:
3. Device signaled monitor mode with a break:
4. Device entered monitor mode:
5. Reset was Power-On Reset:
6. ROM is accesible (un-secured):

[Help...]

☐ Show this dialog before attempting to contact the target 68HC08 board

[Contact target with these settings ...] [Abort]

4. Finally click the "Contact target with these settings…" button and if you are asked to "Erase and program Flash" click "Yes". After that the MCU Flash will be programmed.

1.6.3.2 Programming RG60MCU

The following procedure shows how to load code into the demo board using the serial monitor program that resides in the MC9S08RG60's Flash memory.

1. Before running this demo, please install CodeWarrior for HCS08 Release 3.0 or higher on your PC. Also, please copy the RKEdemoRG60Tx.zip file from the demo board CD to your PC and extract the files into a working folder. The RKEdemoRG60Tx.zip file can be found on the demo board CD in the Documentation directory.
2. Connect a straight-through DB-9 serial cable between COM1 on the PC and the SCI1 connector (DB9 connector) on the demo board. If you are using a different PC COM port, you will need to adjust the settings within the CodeWarrior IDE.
3. Navigate to the working folder and double click the RKEdemoRG60Tx.mcp project. The CodeWarrior IDE will launch.
4. Hold SW1 low while turning the power supply ON. Then release SW1. (If power is already applied, press the reset switch and SW1 simultaneously. Release the reset switch and then release SW1.)
5. Double click on the main.c file in the Sources folder in the project window.
6. Select Debug from the Project menu, or press F5, or click the green arrow on the CodeWarrior tool bar. The True-Time Simulator & Real-Time Debugger initiates serial communications with the demo board. The demo code is erased and re-programmed in the MC9S08RG60's Flash memory. The serial monitor code is not erased. (If the debugger is launched when the board is not powered, you will see a series of error notifications. Cancel and close these messages; close the debugger window; and go back to step 4.)
7. Disconnect the serial cable from the demo board.

The serial monitor can be used for much more than just programming new code without requiring a special debug pod. Many debug operations (memory modifies breakpoints, real-time bug traces, etc.) can also be run over the serial cable while in this mode. Refer to application note AN2140 for more information on the serial monitor.

1.6.3.3 Programming AP64MCU

1. Use the MON08 monitor to install RKEdemoAP64Rx program. The MON08 monitor allows a user to program the MCU Flash and debug application via serial connection.
2. Copy and open the “RKEdemoAP64Rx.zip” file to your PC, and extract the files into a working folder on your desktop.

NOTE

Be sure to extract, and not just copy, the files.

3. If you have not already done so, connect serial cable and apply power to the board.
4. In the working folder on the desktop, double click on the “RKEdemoAP64Rx.mcp” project file. The CodeWarrior IDE will launch.
5. Open “RKEdemoAP64Rx.c” in the source folder by double clicking on it.
6. Please change the jumpers on the board to ensure proper communication between the PC and DEMO908AP64 board.

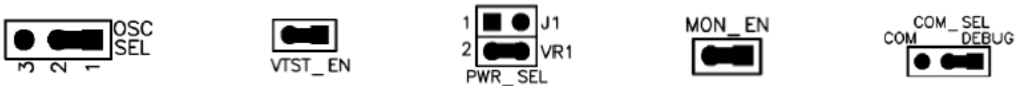


Figure 1-5. MON08 Debug Setting for Serial Connection

7. Click on “Debug” under Project in the menu bar or hit “F5.” The True-Time Simulator & Real-Time Debugger interface window will appear. The “Attempting to contact target and pass security…” window should appear. Please make sure the following options are configured correctly:
   - Target Hardware Type: Class 3
   - Serial Port: 1 (Depends on the PC COM Port)
   - Baud: 9600 Baud
   - Target MCU Security bytes: Check the “IGNORE security failure and enter monitor mode” checkbox.
8. Click the “Contact target with these settings…” button and follow the instructions on the screen. When the “Erase and Program Flash?” window appears, click the “Yes” button.
9. To cycle the power, you should remove the VR1 jumper (PWR_SEL port) and reinstall the VR1 jumper (PWR_SEL). This action has turned the MCU supply power off and on. The + 5-V LED will stay on during this power cycle. Click “OK” in the “Power Cycle Dialog” window.
10. The “CPROG08SZ Programmer” window should close after the MCU Flash is programmed. You are now ready to run the DEMO908AP64_ATD code.

1.6.3.4 Operating the RKE / Remote Sensing Demo

This demo is compounded by two transmitters and one receiver. When the push button one ‘PS1’ is pressed on the MC908QF4EVB the ‘open’ command is sent over the RF link. If push button two ‘PS2’ is pressed the ‘close’ command is sent. The red LED ‘LED1’ turns on every time one of these buttons has been pressed. The green ‘LED2’ will turn on every time the potentiometer is set to a different level. This indicates that the value present on the ADC channel has been updated and sent over the RF link.

As a result of moving the switch ‘S2’ from position one to position two on the Tx2 (MCU-RG60 and Tango3 attached to the baseboard) an ‘open’ command is sent. If the ‘S2’ switch is moved from position 2 to position 1 a ‘closed’ command is sent. The Tx2 can also send the value of the key pressed on the keypad, every time a key is pressed its value will be sent to over the RF link.

The receiver will show the relay status, the analog value, rolling counter, MAC as well as the key pressed on the RG60-Tango3 transmitter.

1.6.3.5 Operating the Home Connectivity Demo

Both transmitters have the same functionality. Both transmitters can send ‘open’, ‘close’ commands, send the potentiometer value and select which receiver will be enabled to execute commands or update values.

When the push button one ‘PS1’ is pressed on the transmitters the ‘open’ command is sent over the RF link. If push button two ‘PS2’ is pressed the ‘close’ command is sent. The red ‘LED1’ turns on every time one of these buttons has been pressed. The green ‘LED2’ will turn on every time the potentiometer is set to a different level. This indicates that the value present on the ADC channel has been updated and sent over the RF link.

Transmitters enter to ‘select receiver’ mode when ‘PS1’ and ‘PS2’ are simultaneously pressed, the ‘LED1’ and ‘LED2’ will turn on indicating this state. The transmitter will remain on this state for three seconds, if any push button has not been pressed during this time the Tx will enable both receivers for executing the sent commands. Pressing push button one before this time expires, it will select Rx1; pressing push button two will select Rx2.

Chapter 2
Operational Description

2.1 Introduction

The RF development platform provides a general-purpose platform that allows the user to prototype and demonstrates many different applications. It reuses the Tango3 and Romeo2 development tools reducing development time/costs and maintaining compatibility with off the shelf development tools.

This section describes the electrical characteristics, user interfaces, and connections for the RF Development Platform.

2.2 Baseboard

2.2.1 Electrical Characteristics

The baseboard must be fed with an AC/AC power adaptor, typically 7.5 Vac output.

Table 2-1. Baseboard Electrical Characteristics

Inputs/Outputs	Min	Typ	Max	Unit
AC input voltage	7	7.5	8	Vac
AC current consumption	50	150	—	mA
Triac voltage (J9)	—	—	300	Vac
Triac current (J9)	—	—	2	A
Relay voltage (J7)	—	—	250	Vac
Relay current (J7)	—	—	2	A
Input voltage signal booster (J8)	—	—	3	V_{PP}

2.2.2 User Interfaces (Keypad, LCD, Jumpers, etc.)

The baseboard user interface consists of one keypad, one LCD, one buzzer, one potentiometer and two switches.

- Keypad — A keypad with 12 keys, number from ‘0’ to ‘9’ and the special characters ‘#’ and ‘*’.
- LCD — A 16 characters per 2 lines liquid crystal display
- BUZZER — A buzzer for general propose
- POT — Potentiometer for general propose
- S1 and S2 — Two switches for general propose

2.2.2.1 Jumper Description

Table 2-2 provides a functional description of each jumper located in the baseboard.

Table 2-2. Baseboard Jumper Descriptions

Jumper Name	Functional Description
JP1	Connects the switch 2 (S2) to pin 37 (SW2) of the 40-pin connectors
JP2	Connects the TxD RS-232 interface to pin 5 (TXD) of the 40-pin connectors
JP3	Connects the RxD RS-232 interface to pin 7 (RXD) of the 40-pin connectors
JP4	Connects the keypad row 1 to pin 40 (ROW1) of the 40-pin connectors
JP5	Connects the keypad row 2 to pin 31 (ROW2) of the 40-pin connectors
JP6	Connects the keypad row 3 to pin 33 (ROW3) of the 40-pin connectors
JP7	Connects the keypad row 4 to pin 36 (ROW4) of the 40-pin connectors
JP8	Connects the keypad column 1 to pin 30 (COL1) of the 40-pin connectors
JP9	Connects the keypad column 2 to pin 35 (COL2) of the 40-pin connectors
JP10	Connects the keypad column 3 to pin 32 (COL3) of the 40-pin connectors
JP11	Connects the keypad interrupt signal to pin 2 ($\overline{\mathrm{IRQ}}$) of the 40-pin connectors
JP12	Connects the T2IN to R2OUT pins of the RS-232 transceiver (IC1)
JP13	Connects the buzzer to pin 39 (BUZ/LED8) of the 40-pin connectors
JP14	Connects the zero-cross detection to pin 9 (KBI) of the 40-pin connectors
JP15	Connects the switch 1 (S1) to pin 26 (CAN/LIN_TX/SW1) of the 40-pin connectors
JP16	Connects the opto-sensor to pin 22 (OPTO_SENSOR) of the 40-pin connectors
JP17	Connects the TRIAC to pin 34 (TRIAC) of the 40-pin connectors
JP18	Connects the relay to pin 29 (RELAY) of the 40-pin connectors
JP19	Connects the LED 1 to pin 28 (CAN/LIN_RX/LED1) of the 40-pin connectors
JP20	Connects the LED 2 to pin 6 (LED2) of the 40-pin connectors
JP21	Connects the LED 3 to pin 8 (LED3) of the 40-pin connectors
JP22	Connects the LED 4 to the LED4 trace (pin 3 JP30, pin 1 JP31)
JP23	Connects the LED 5 to pin 19 (LED5/MISO) of the 40-pin connectors
JP24	Connects the LED 6 to pin 21 (LED6/SCLK) of the 40-pin connectors
JP25	Connects the LED 7 to pin 23 (LED7/$\overline{\mathrm{SS}}$) of the 40-pin connectors
JP26	Connects the LED 8 to pin 1 of the JP32
JP27	Connects the OpAmp out to pin 18 (OPAMP_SENSOR) of the 40-pin connectors
JP28	Connects the potentiometer to pin 20 (POT) of the 40-pin connectors
JP29	Placed in position 1-2 for use of 5 V or in position 2–3 for use of 3.3-V in 40-pin connector (ROMEO/ECHO: J4)
JP30	Placed in position 1–2 connects the pin 15 (DATA_T) of the J1 & J2 40-pin connectors to the pin 15 (TCH1) of the J3 and J4 40-pin connectors. Placed in position 2–3 connects the pin 15 (TCH1) of the J3 & J4 40-pin connectors to the LED4 trace (pin 1 JP22, pin 1 JP31).
JP31	Connects the pin 17 (MOSI) of the 40-pin connectors to the LED4 trace (pin 1 JP22, pin 3 JP30)
JP32	Placed in position 1–2 connects the LED8 trace (pin 1 JP26) to the pin 39 (BUZ/LED8) of the 40-pin connectors. Placed in position 2–3 connects the buzzer to the pin 39 (BUZ/LED8) of the 40-pin connectors.

2.2.3 Connector Pin Descriptions

2.2.3.1 SCI1 — RS-232 Interface Connector

Table 2-3. RS-232 DB-9 Connector (SCI1)

Pin Number	Name	Description
1	CD	Bridged with pins 4 and 6
2	RxD	Data received by the PC from the control board
3	TxD	Data transmitted from the PC to the control board
4	DTR	Bridged with pins 1 and 6
5	GND	Common ground reference
6	DSR	Bridged with pins 1 and 4
7	RTS	Optional handshake signal
8	CTS	Optional handshake signal
9	Unused	N/A

2.2.3.2 J1 — 3.3-V MCU 40-Pin Male Header

Table 2-4. 3.3-V MCU 40-Pin Male Header (J1)

Pin Number	Name	Description
1	+3.3V	3.3-V voltage source
2	$\overline{\text{IRQ}}$	External interrupt request pin
3	GND	Ground reference
4	$\overline{\text{RESET}}$	MCU reset pin
5	TXD	Transmit data of SCI
6	LED2	Yellow LED turn on/off pin
7	RXD	Receive data of SCI
8	LED3	Orange LED turn on/off pin
9	KBI	Keyboard Interrupt pin
10	D4	Data pin for LCD interface
11	ENABLE_T/STROBE_R	Tango standby/on control. Romeo strobe oscillator control.
12	D5	Data pin for LCD interface
13	DATACLK_T/AGC_R	Tango clock available for the MCU. Romeo AGC modulation selection.
14	D6	Data pin for LCD interface
15	DATA_T	Tango data input.
16	D7	Data pin for LCD interface
17	MOSI	Master out/slave in pin of SPI
18	OPAMP_SENSOR	ADC input from signal boosting circuitry

Table 2-4. 3.3-V MCU 40-Pin Male Header (J1) (Continued)

Pin Number	Name	Description
19	LED5/MISO	Orange LED turn on/off pin. Master in/slave out pin of SPI
20	POT	ADC input from potentiometer
21	LED6/SCLK	Yellow LED turn on/off pin. Serial clock pin of SPI
22	OPTO_SENSOR	ADC input from opto-resistor
23	LED7 / $\overline{\text{SS}}$	Orange LED turn on/off pin. Slave select pin of SPI
24	E	Enable pin for LCD interface
25	MODE_T/ENABLELNA_R	Tango FSF or OOK modulation selection. Romeo LNA bias control.
26	CAN/LIN_TX/SW1	Transmit pin of CAN interface. Transmit pin of LIN interface. On/off switch input pin.
27	ENABLEPA_T/RESETB	Tango enable power amplifier. Romeo SPI mode selection.
28	CAN/LIN_RX/LED1	Receive pin of CAN interface. Receive pin of LIN interface. Orange LED turn on/off pin
29	RELAY	Relay control pin
30	COL1	Column 1 pin for keypad
31	ROW2	Row 2 pin for keypad
32	COL3	Column 3 pin for keypad
33	ROW3	Row 3 pin for keypad
34	TRIAC	TRIAC trigger control pin.
35	COL2	Column 2 pin for keypad
36	ROW4	Row 4 pin for keypad
37	SW2	On/off switch input pin
38	RS	Data or instruction select pin for LCD interface
39	BUZ/LED8	Buzzer control pin. Yellow LED turn on/off pin
40	ROW1	Row 1pin for keypad

2.2.3.3 J2 — TANGO / ECHO 40-Pin Female Header

The TANGO / ECHO 40-pin female header J2 has the same pinout as the 3-V MCU 40-pin male header (J1).

2.2.3.4 J3 — 5V MCU 40-Pin Male Header

The 5-V MCU 40-pin male header has the same pinout as the 3-V MCU 40-pin male header (J1) except for the pin 1. Pin 1 is the 5-V voltage source.

2.2.3.5 J4 — ROMEO / ECHO 40-Pin Female Header

The ROMEO / ECHO 40-pin female header has the same pinout as the 3-V MCU 40-pin male header (J1) except for the pin 1. Pin 1 is connected to jumper JP29. It can be selected 5-V or 3.3-V voltage source.

2.2.3.6 J5 — LCD Connector

Table 2-5. LCD Connector (J5)

Pin Number	Name	Description
1	V_{SS}	GND — ground reference
2	V_{DD}	LCD contrast
3	V_o	Ground reference
4	R_S	MCU reset pin
5	$R / \overline{W}$	Data read/write. Tied to GND (write)
6	E	Enable
7	D0	Data bus pin 0. Not connected.
8	D1	Data bus pin 1. Not connected.
9	D2	Data bus pin 2. Not connected.
10	D3	Data bus pin 3. Not connected.
11	D4	Data bus pin 4
12	D5	Data bus pin 5
13	D6	Data bus pin 6
14	D7	Data bus pin 7
15	A	Backlight anode
16	K	Backlight cathode

2.2.3.7 J6 — AC Jack

Table 2-6. AC Jack (J6)

Pin Number	Name	Description
1	AC1	7.5 AC
2	AC2	7.5 AC
3	—	Bridged with pin 2

2.2.3.8 J7 — Relay Connector

Table 2-7. Relay Connector (J7)

Pin Number	Name	Description
1	Line	I/O pin signal
2	Load	I/O pin signal

2.2.3.9 J8 — Signal Booster Connector

Table 2-8. Signal Booster Connector (J8)

Pin Number	Name	Description
1	Positive	Positive differential input
2	Negative	Negative differential input

2.2.3.10 J9 — TRIAC connector

Table 2-9. Triac Connector (J9)

Pin Number	Name	Description
1	Load	I/O pin signal
2	Line	I/O pin signal

2.3 MC68HC908QF4

2.3.1 Electrical Characteristics

Table 2-10. MC68HC908QF4 Electrical Characteristics

Inputs/Outputs	Min	Typ	Max	Units
DC battery supply voltage	8	9	12	Vdc
DC external voltage	3	3.3	3.6	Vdc
Minimum logic 1 input voltage	2.1	—	—	Vdc
Maximum logic 0 input voltage	—	—	0.9	Vdc
Antenna Impedance	—	50	—	—
Board current consumption	—	11.8	35	mA
RS-232 connection speed	—	9600	—	Baud

2.3.2 User Interfaces (Keypad, LCD, Jumpers, etc.)

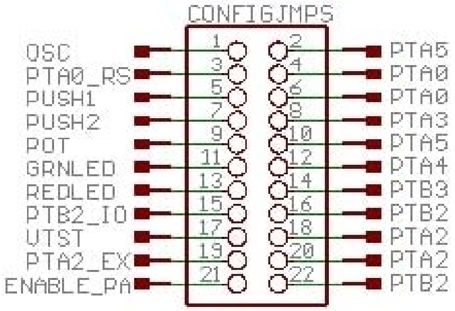
The MC908QF4 EVB user interface consists of two light-emitting diodes (LEDs), one potentiometer, and two push buttons.

- SW1 is a push button located in the bottom left corner next to the battery holder. It is used to send close commands and to select the receiver. This function depends on the demo software loaded to the QF4 MCU.
- SW2 is a push button located next to the SW1; it is used to send open commands and to select the receiver. This function depends on the demo software loaded to the QF4 MCU.
- LED1 is a green-light emitting diode located in the bottom left corner next to the battery holder and below the two push buttons. It is used to indicate a reading on the potentiometer value and the transmission of this value over the RF link.
- LED2 is a red-light emitting diode located next to the LED1. It is used to indicate a transmission of the ‘open/close’ commands.
- R21 is a potentiometer located next to the battery holder in the left side of the MC908QF4 EVM. It is used to change the analog value present on the ADC module.

2.3.2.1 Jumper Description

Table 2-11 provides a functional description of each jumper located in the MC908QF4 EVB

Table 2-11. MC908QF4EVB Jumper Descriptions

Jumper Name	Functional Description	
J1	Connects the 9.8304 MHz external oscillator to PTA5.	 CONFIGJMPS OSC PTA0_RS PUSH1 PUSH2 POT GRNLED REDLED PTB2_IO VTST PTA2_EX ENABLE_PA 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 PTA5 PTA0 PTA0 PTA3 PTA5 PTA4 PTB3 PTB2 PTA2 PTA2 PTB2
J2	Connects PTA0 to the RS-232 serial data line.	
J3	Set this jumper to enable pushbutton SW1, it connects SW1 to PTA0.	
J4	Set this jumper to enable pushbutton SW2, it connects SW2 to PTA3.	
J5	Set this jumper to connect the potentiometer to PTA5.	
J6	Set this jumper to enable LED2, it connects LED2 to PTA4.	
J7	Set this jumper to enable LED1, it connects LED1 to PTB3.	
J8	Connects PTB2 to the 40-pin connector.	
J9	Connects PTA2 to V_{TST}, the voltage necessary to program the Flash through serial monitor.	
J10	Connects PTA2 to the multilink high-voltage pin. It also connects PTA2 to the 40-pin connector.	
J11	Connects PTB2 to the Enable_PA pin, which enables or disables the RF power amplifier. If this jumper is set, and the output of PTB2 is high, the power amplifier is enabled. Otherwise, the power amplifier is disabled.	
VSEL	Set jumper in position 1–2 for use with on board 9-V battery. For use with an external 3.3-V voltage source, set jumper in position 2–3.	
ON/OFF	When not using the board, take off this jumper to avoid discharging the 9-V on-board battery. This jumper has no effect when using an external 3.3-V voltage source connected to VCONCTR.	

2.3.3 Connector Pin Descriptions

Table 2-12. External Connector Voltage

Pin Number	Name	Description
1	GND	Common ground reference
2	V_{CC}	External 3.3-V supply voltage

Table 2-13. MON08 (Multilink Connector)

Pin Number[1]	Name	Description
2	GND	Common ground reference
6	PTA2_EX	High-voltage for programming (V_{TST})
8	PTA0	Dedicated pin for serial communication
13	PTA5	External clock
15	V_{CC}	Supply voltage

NOTES:
1. Unused pins are not mentioned.

Table 2-14. RS-232 Serial Interface DB-9 Connector

Pin Number	Name	Description
1	Unused	N/A
2	Serial_Out	Data transmitted from the board to the PC
3	Serial_In	Data received by the board from the PC
4	DTR	Enables/disables V_{MCU} power in the board
5	GND	Common ground reference
6	Unused	N/A
7	Unused	N/A
8	Unused	N/A
9	Unused	N/A

Table 2-15. 40-Pin Connector

Pin Number[1]	Name	Description
1	V_{MCU}	N/A
2	PTA2_EX	If J10 is placed, this pin connects to PTA2
3	GND	N/A
9	PTA3	N/A
10	PTB4	N/A
12	PTB5	N/A
13	PTA0	N/A
14	PTB6	N/A
16	PTB7	N/A
18	PTA5	N/A
24	PTA4	N/A
38	PTB3	N/A
40	PTB2_IO	If J8 is placed, this pin connects to PTB2

Chapter 3
Schematics and Bill of Materials

3.1 MC908QF4 EVB

3.1.1 MC908QF4 EVB Schematic Diagrams

The schematics for the MC908QF4EVB board appear in Figure 3-1 and Figure 3-2. The schematic in Figure 3-2 is for the high-power version of the board.

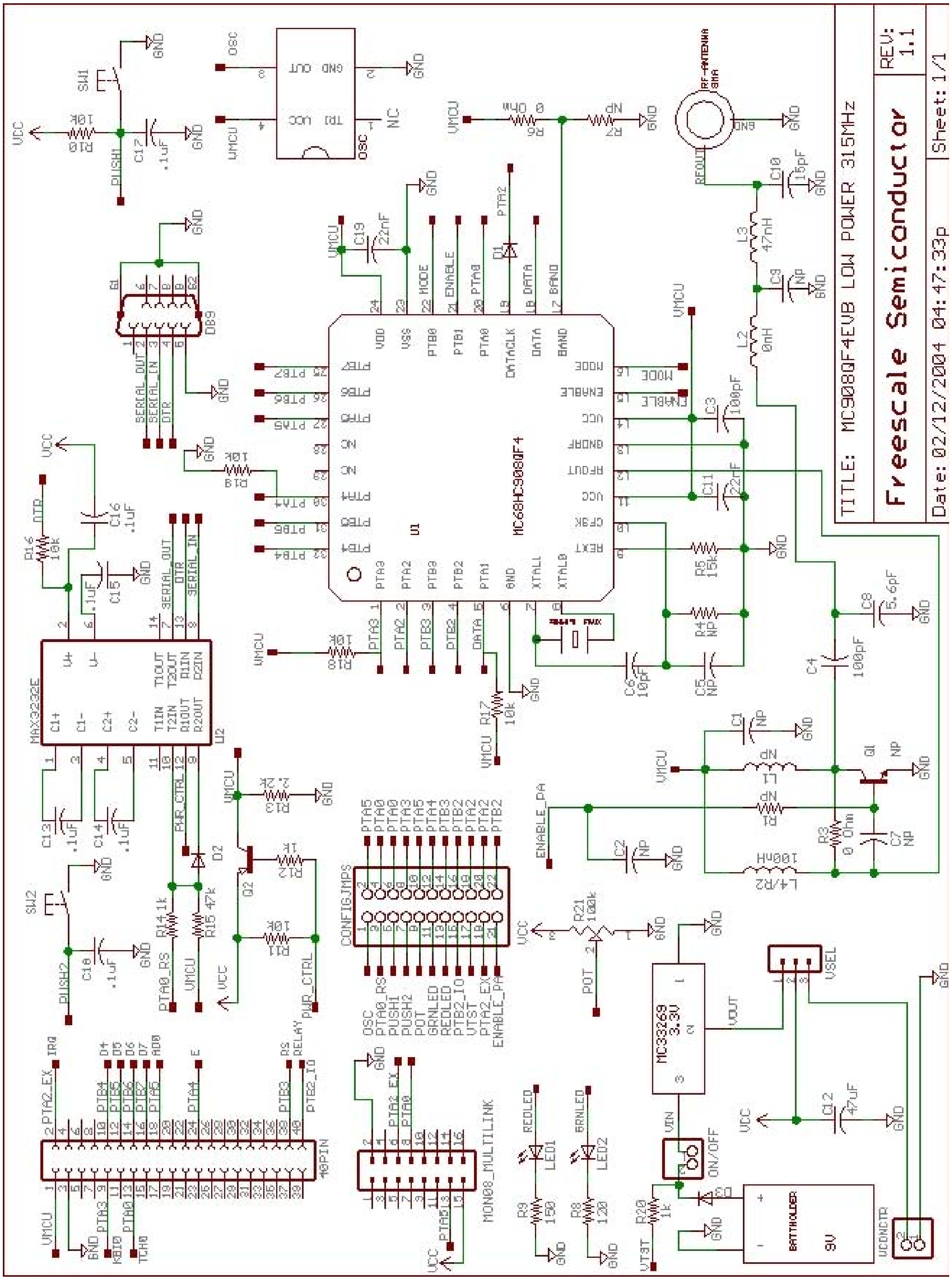


Figure 3-1. MC908QF4EVB Low-Power Schematic

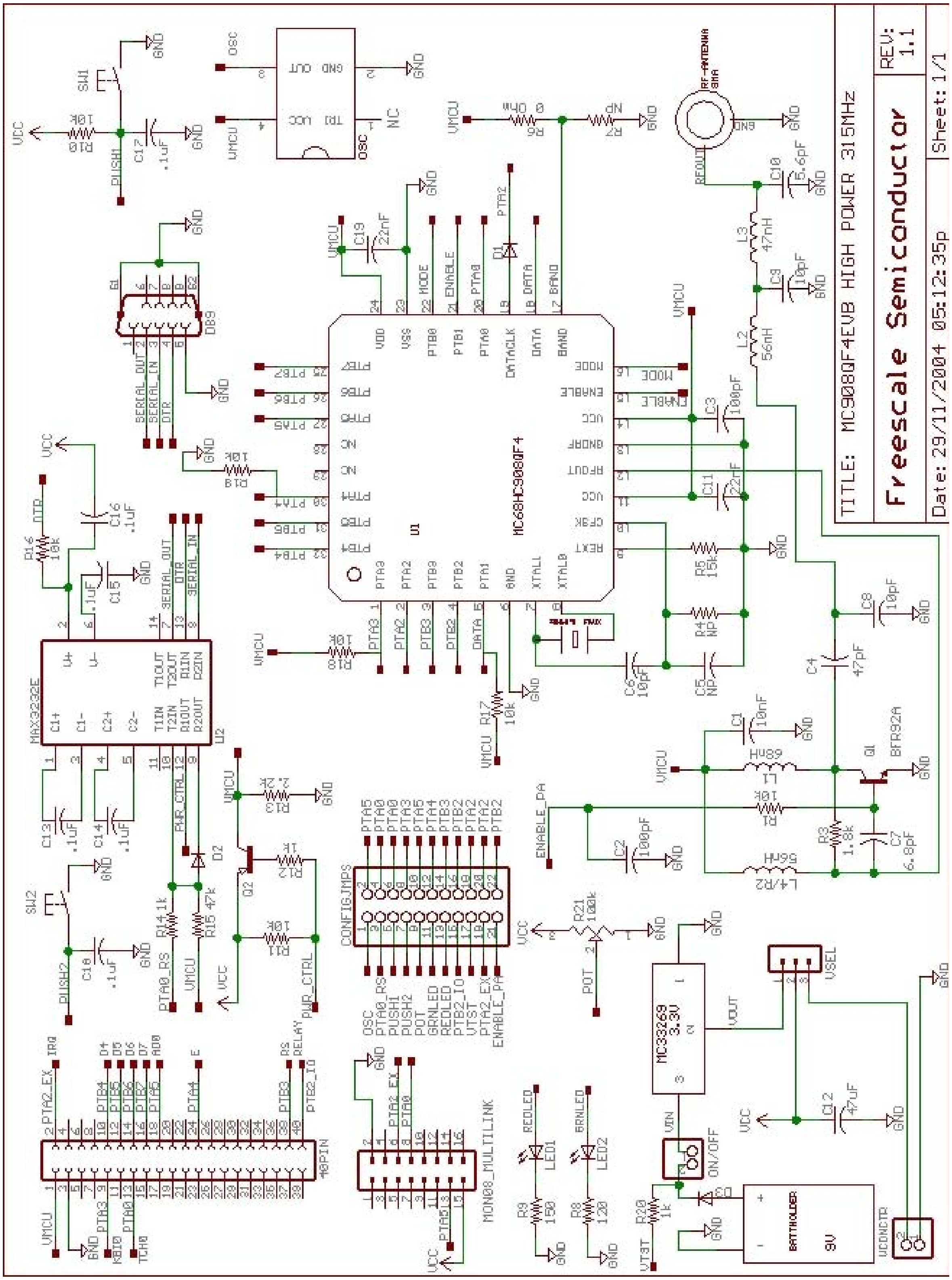


Figure 3-2. MC908QF4EVB High-Power Schematic

3.1.2 MC908QF4 EVB Bill of Materials

The MC908QF4EVB board bill of materials (BOM) low-power version is described in Table 3-1. The high-power version has only 14 components different from the low-power version, Table 3-2 shows those changes.

Table 3-1. Bill of Materials for MC908QF4EVB Low-Power Version (Sheet 1 of 3)

Item	Qty	Reference Designator	Description	Manufacturer	Part Number	Value	Tolerance	Rating	Footprint
1	1	C1	0603 SIZE SMT CERAMIC CAPACITOR	Any		NP			0603
2	1	C2	0603 SIZE SMT CERAMIC CAPACITOR	Any		NP			
3	2	C3 C4	0603 SIZE SMT CERAMIC CAPACITOR	Any		100 pF	5%	50 V NPO	0603
4	3	C5 C7 C9	0603 SIZE SMT CERAMIC CAPACITOR	Any		NP			0603
5	1	C6	0603 SIZE SMT CERAMIC CAPACITOR	Any		10 pF	±0.25 pF	50 V NPO	0603
6	1	C8	0603 SIZE SMT CERAMIC CAPACITOR	Any		5.6 pF	±0.25 pF	50 V NPO	0603
7	1	C10	0603 SIZE SMT CERAMIC CAPACITOR	Any		15 pF	±0.25 pF	50 V NPO	0603
8	1	C11	0603 SIZE SMT CERAMIC CAPACITOR	Any		22 nF	10%	25 V X7R	0603
9	1	MON08	2 BY 08 .10" PITCH HEADER	SULLINS	PZC08DAAN				HEADER 2X8
10	1	CONFIGJMPS	2 BY 11 .10" PITCH HEADER	SULLINS	PZC11DAAN				HEADER 2X11
11	1	ON/OFF	1 BY 2 .10" PITCH HEADER	SULLINS	PZC02SAAN				HEADER 1X2
12	1	VSEL	1 BY 3 .10" PITCH HEADER	SULLINS	PZC03SAAN				HEADER 1X3
13	1	VCONCTR	1 BY 2 .10" PITCH HEADER	SULLINS	PZC02SAAN				HEADER 1X2
14	1	40PIN	2 BY 20 .10" SMD FEMALE HEADER	SAMTEC	SSM-120-L-DV-BE-K				HEADER 2X20
15	1	DB9	PBC MOUNT RIGHT ANGLE DB9 FEMALE	AMPHENOL	617-C009S-AJ120				DB9
16	1	SMA CONNECTOR	0.062 NARROW EDGE MOUNT SMA CONNECTOR	JOHNSON COMPONENTS	142-0711-821				SMA-NARROW
17	1	L1	0603 SIZE CHIP INDUCTOR	TOKO		NP			0603
	or		LEAD FREE VERSION						

Table 3-1. Bill of Materials for MC908QF4EVB Low-Power Version (Sheet 2 of 3)

Item	Qty	Reference Designator	Description	Manufacturer	Part Number	Value	Tolerance	Rating	Footprint
18	1	L2	0603 SURFACE MOUNT ZERO OHM JUMPER			0 Ω			0603
	or		LEAD FREE VERSION						
19	1	L3	0603 SIZE CHIP INDUCTOR	TOKO	LL1608-FS47NJ	47 nH	5%		0603
	or		LEAD FREE VERSION		LL1608-FSL47NJ				
20	1	L4/R2	0603 SIZE CHIP INDUCTOR	TOKO	LL1608-FSR10J	100 nH	5%		0603
	or		LEAD FREE VERSION		LL1608-FSLR10J				
21	1	Q1	WIDEBAND NPN TRANSISTOR	PHILIPS		NP			SOT23
22	1	R1	0603 SURFACE MOUNT RESISTOR	Any		NP			0603
23	1	R3	0603 SURFACE MOUNT ZERO OHM JUMPER	Any		0 Ω	5%	1/16 Ω	0603
24	2	R4, R7	0603 SURFACE MOUNT RESISTOR	Any		NP			0603
25	1	R5	0603 SURFACE MOUNT RESISTOR	Any		15 k			0603
26	1	R6	0603 SURFACE MOUNT ZERO OHM JUMPER	Any		0 Ω			0603
27	1	U1	UHF TRANSMITTER AND MCU	FREESCALE	MC68HC908QF4				LQFP
28	1	X1	SMT QUARTZ CRYSTAL	CRYSTEK CORPORATION	017113	9.843750 MHz	±30 ppm	C_L 18 pF	HC49S SMD
29	1	PCB1	.062" DOUBLE SIDED FR-4 PRINTED CIRCUIT BD		MC908QF4 rev B				
30	1	LED1	HEWLETT-PACKARD HSMS-C650	HEWLETT PACKARD	HSMS-C650				3.20 x 1.60 mm
31	1	LED2	HEWLETT-PACKARD HSMG-C650	HEWLETT PACKARD	HSMG-C650				3.20 x 1.60 mm
32	2	D1 D2	SCHOTTKY DIODE (HIGH-SPEED & LOW VF)	ON SEMI-CONDUCTOR	BAT54XV2T1				SOD523
33	1	D3	1A DIODE RECTIFIER	DIODES INC.	S1ABDICT-ND				SMB
34	2	SW1, SW2	SQUARE TYPE TACT SWITCH	ALPS	SKHMPUE010				CUSTOM
35	1	R21	POTENTIOMETER	ALPHA (TAIWAN)	317-2090-100K	100 k	20%	0.1 Ω	CUSTOM
36	1	RS-232	RS-232 TRANSCEIVER	MAXIM	MAX3232E			3.3 V	16 WIDE .300" SOIC
37	1	MC33269	3.3V LOW DROPOUT VOLTAGE REGULATOR	ON SEMI-CONDUCTOR	MC33269DT-3.3			3.3 V	CUSTOM
	or		LEAD FREE VERSION		MC33269DT-3.3G				

Table 3-1. Bill of Materials for MC908QF4EVB Low-Power Version (Sheet 3 of 3)

Item	Qty	Reference Designator	Description	Manufacturer	Part Number	Value	Tolerance	Rating	Footprint
38	1	BATTHOLDER	PLASTIC 9V BATTERY HOLDER	KEYSTONE ELECTRONICS	1294				CUSTOM
39	1	Q2	PNP GENERAL PURPOSE TRANSISTOR	ON SEMI-CONDUCTOR	BC80740LT1				SOT23
	or		LEAD FREE VERSION		BC80740LT1G				
40	1	C12	VERTICAL ELECTROLYTIC CAPACITOR	ELNA	RV2-16V470M-R	47 µF		16 V	CUSTOM
41	6	C13, C14, C15, C16, C17, C18	0805 SIZE SMT CERAMIC CAPACITOR	Any		0.1 µF	10%	50 V X7R	0805
42	1	C19	0603 SIZE SMT CERAMIC CAPACITOR	Any		22 nF	10%	25 V X7R	0603
43	1	R8	0603 SURFACE MOUNT RESISTOR	Any		120 Ω	5%	1/16 Ω	0603
44	1	R9	0603 SURFACE MOUNT RESISTOR	Any		150 Ω	5%	1/16 Ω	0603
45	6	R10, R11, R16, R17, R18, R19	0603 SURFACE MOUNT RESISTOR	Any		10 k	5%	1/16 Ω	0603
46	1	R15	0603 SURFACE MOUNT RESISTOR	Any		47 k	5%	1/16 Ω	0603
47	1	R13	0603 SURFACE MOUNT RESISTOR	Any		2.2 k	5%	1/16 Ω	0603
48	3	R12, R14, R20	0603 SURFACE MOUNT RESISTOR	Any		1 k	5%	1/16 Ω	0603
49	1	OSC	SMD OSCILLATOR	CITIZEN	CMX-309FB	9.830 MHz		3.3 V	CUSTOM
50	1		ANTENNA	NEARSON	L324AM-315S				
51	2		STANDOFFS	KEYSTONE ELECTRONICS	2202				
52	10		JUMPERS	SULLINS	SSC02SYAN				
FOR X1 PLEASE USE IF AVAILABLE:			SMT QUARTZ CRYSTAL	NDK SPEC EXS10B-00846	REF LN-G102-950	9.84375 MHz	±50 ppm	C_L 12pF	NDK-NX8045
"NP" IN VALUE FIELD INDICATES COMPONENT POSITION NOT POPULATED									
PLEASE USE LEAD FREE VERSIONS WHERE POSSIBLE									

Table 3-2. Bill of Material Changes for High-Power Version

Item	Qty	Reference Designator	Description	Manufacturer	Part Number	Value	Tolerance	Rating	Footprint
1	1	C1	0603 SIZE SMT CERAMIC CAPACITOR	Any		10 nF	10%	25 V X7R	0603
2	1	C2	0603 SIZE SMT CERAMIC CAPACITOR	Any		100 pF	5%	50 V NPO	0603
3	1	C4	0603 SIZE SMT CERAMIC CAPACITOR	Any		47 pF	5%	50 V NPO	0603
4	1	C7	0603 SIZE SMT CERAMIC CAPACITOR	Any		6.8 pF	±0.25 pF	50 V NPO	0603
5	1	C8	0603 SIZE SMT CERAMIC CAPACITOR	Any		10 pF	±0.25 pF	50 V NPO	0603
6	1	C9	0603 SIZE SMT CERAMIC CAPACITOR	Any		10 pF	± .25 pF	50 V NPO	0603
7	1	C10	0603 SIZE SMT CERAMIC CAPACITOR	Any		5.6 pF	7	1	C10
8	1	L1	0603 SIZE CHIP INDUCTOR	TOKO	LL1608-FS68NJ	68 H	17	1	L1
	or		LEAD FREE VERSION		LL1608-FSL68NJ			or	
9	1	L2	0603 SIZE CHIP INDUCTOR	TOKO	LL1608-FS56NJ	56 nH	18	1	L2
	or		LEAD FREE VERSION		LL1608-FSL56NJ			or	
10	1	L3	0603 SIZE CHIP INDUCTOR	TOKO	LL1608-FS47NJ	47 nH	19	1	L3
	or		LEAD FREE VERSION		LL1608-FSL47NJ			or	
11	1	L4/R2	0603 SIZE CHIP INDUCTOR	TOKO	LL1608-FS56NJ	56 nH	20	1	L4/R2
	or		LEAD FREE VERSION		LL1608-FSL56NJ			or	
12	1	Q1	WIDEBAND NPN TRANSISTOR	PHILIPS	BFR92A	5 GHz			SOT23
13	1	R1	0603 SURFACE MOUNT RESISTOR	Any		10 k	5%	1/16Ω	0603
14	1	R3	0603 SURFACE MOUNT RESISTOR	Any		1.8 k	5%	1/16Ω	0603

3.2 Baseboard

3.2.1 Baseboard Schematics

The schematic diagram of the baseboard is shown in Figure 3-3.

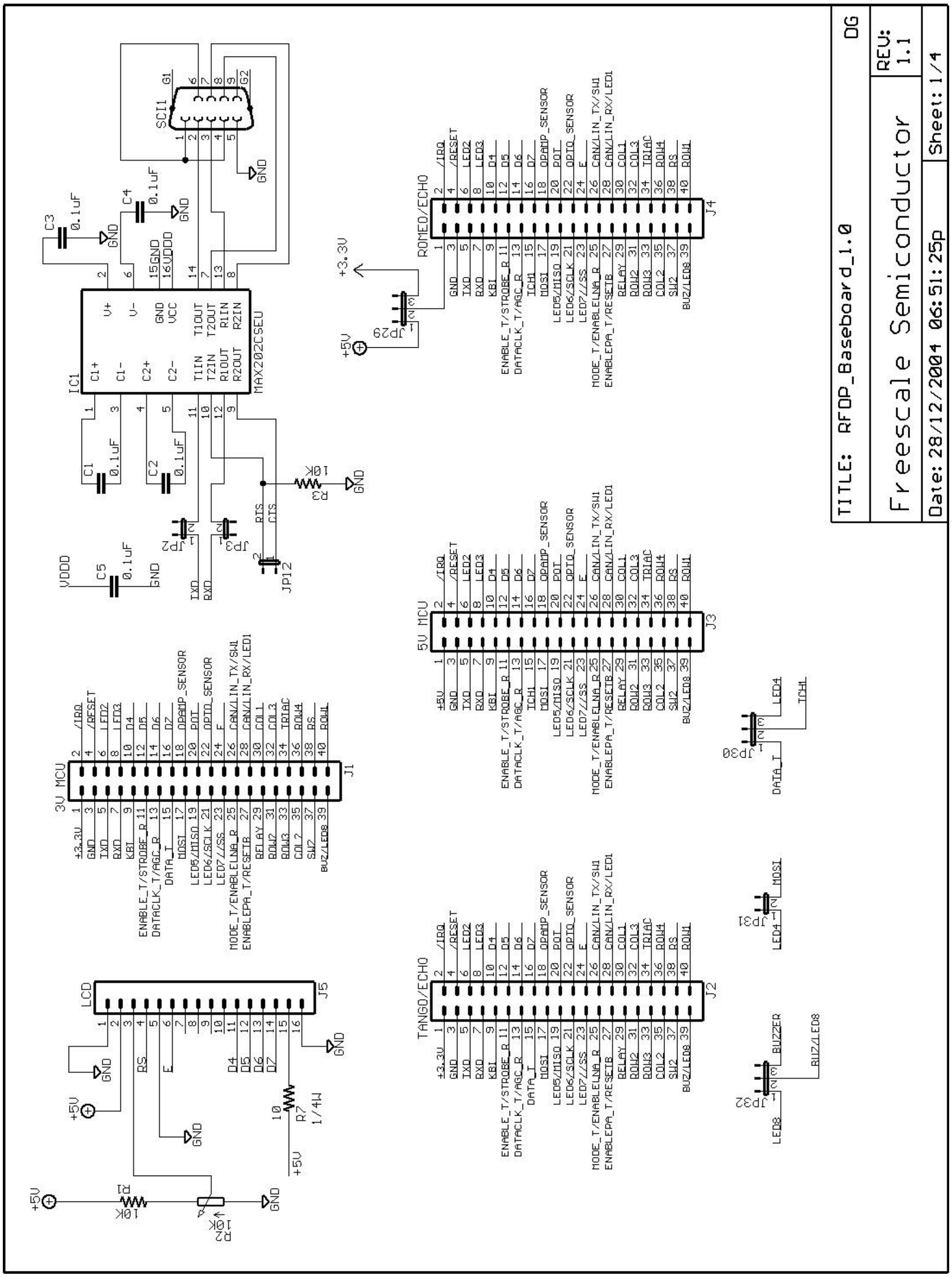


Figure 3-3. Baseboard Schematic (Sheet 1 of 4)

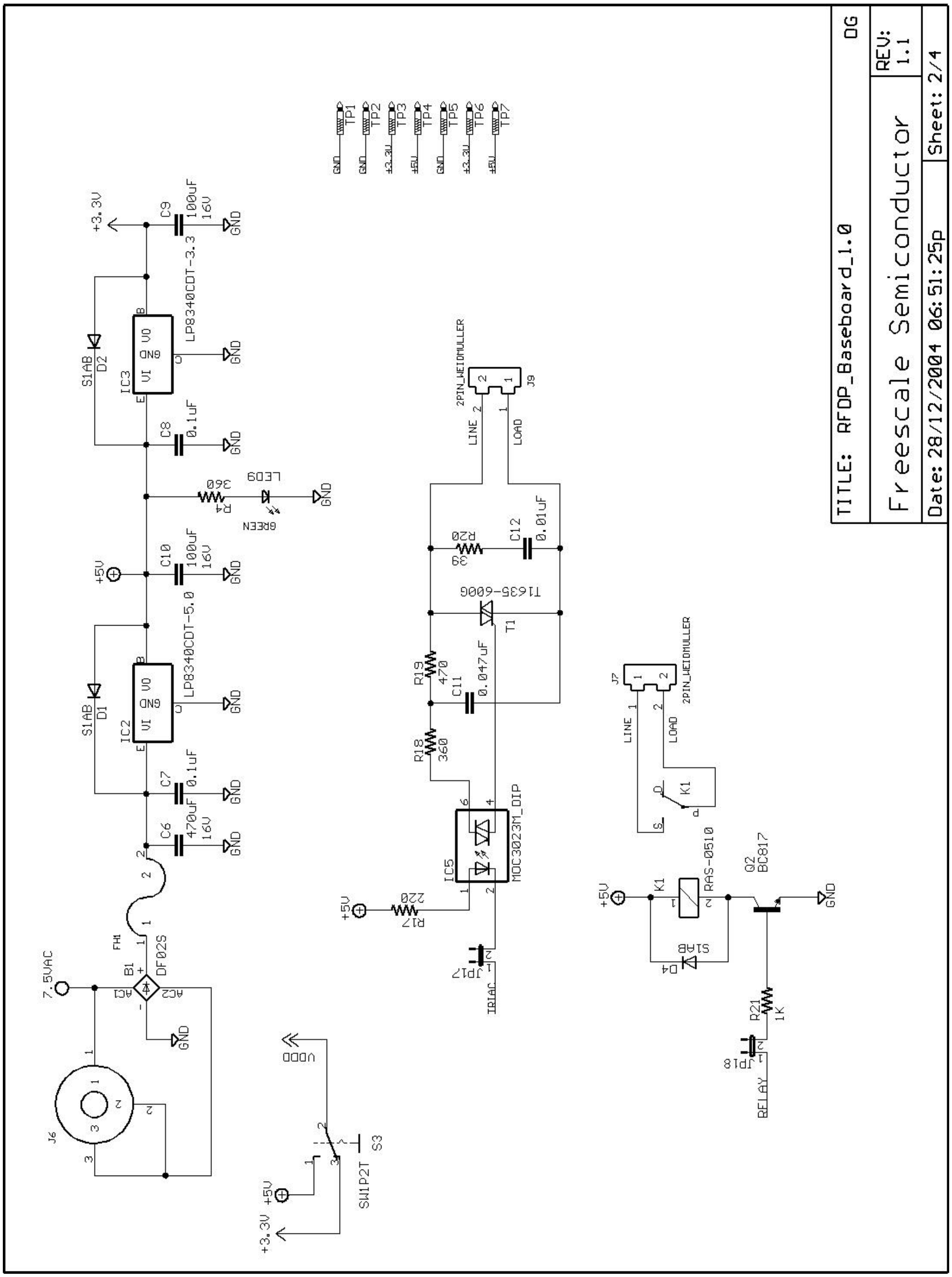


Figure 3-3. Baseboard Schematic (Sheet 2 of 4)

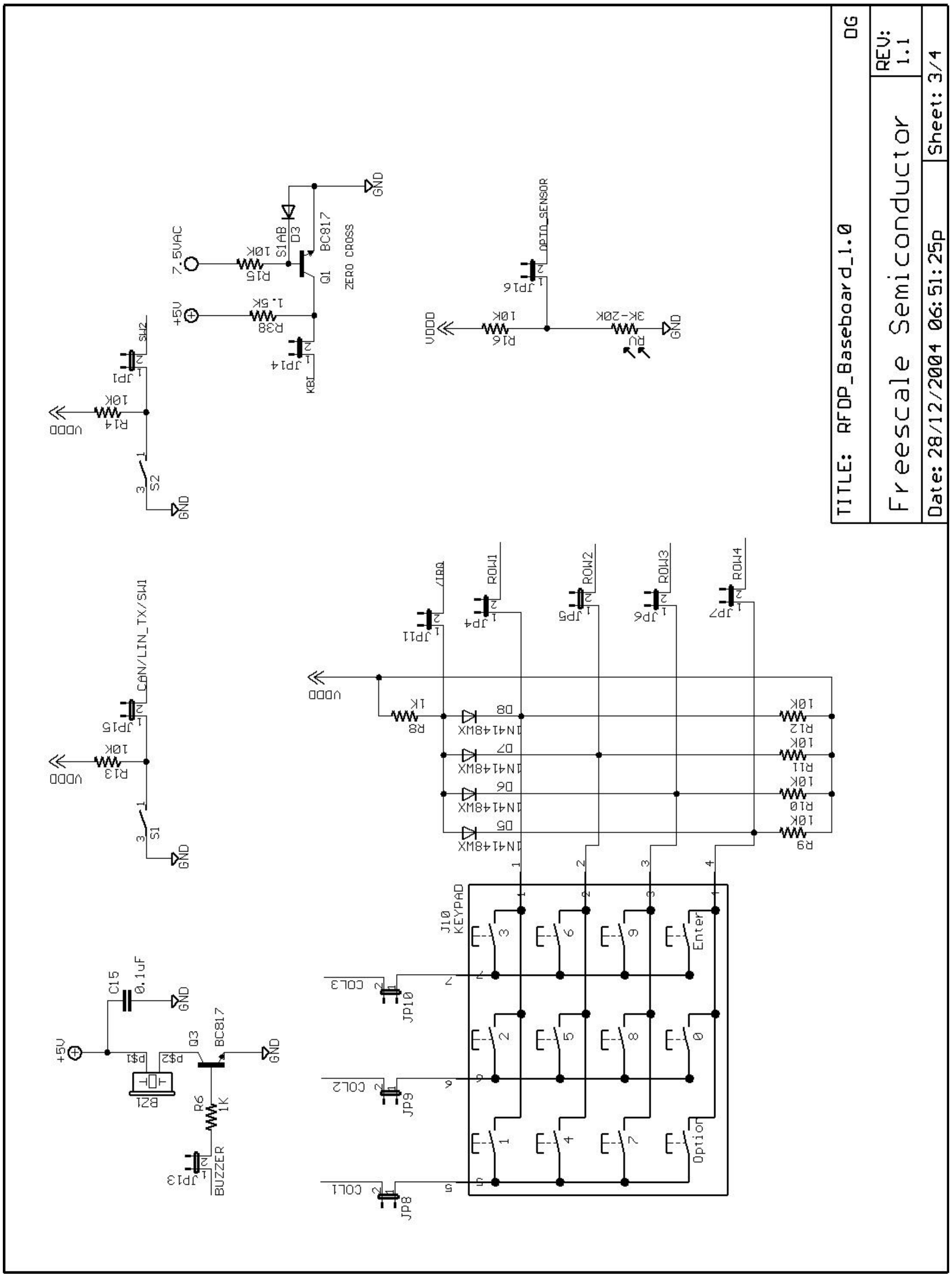


Figure 3-3. Baseboard Schematic (Sheet 3 of 4)

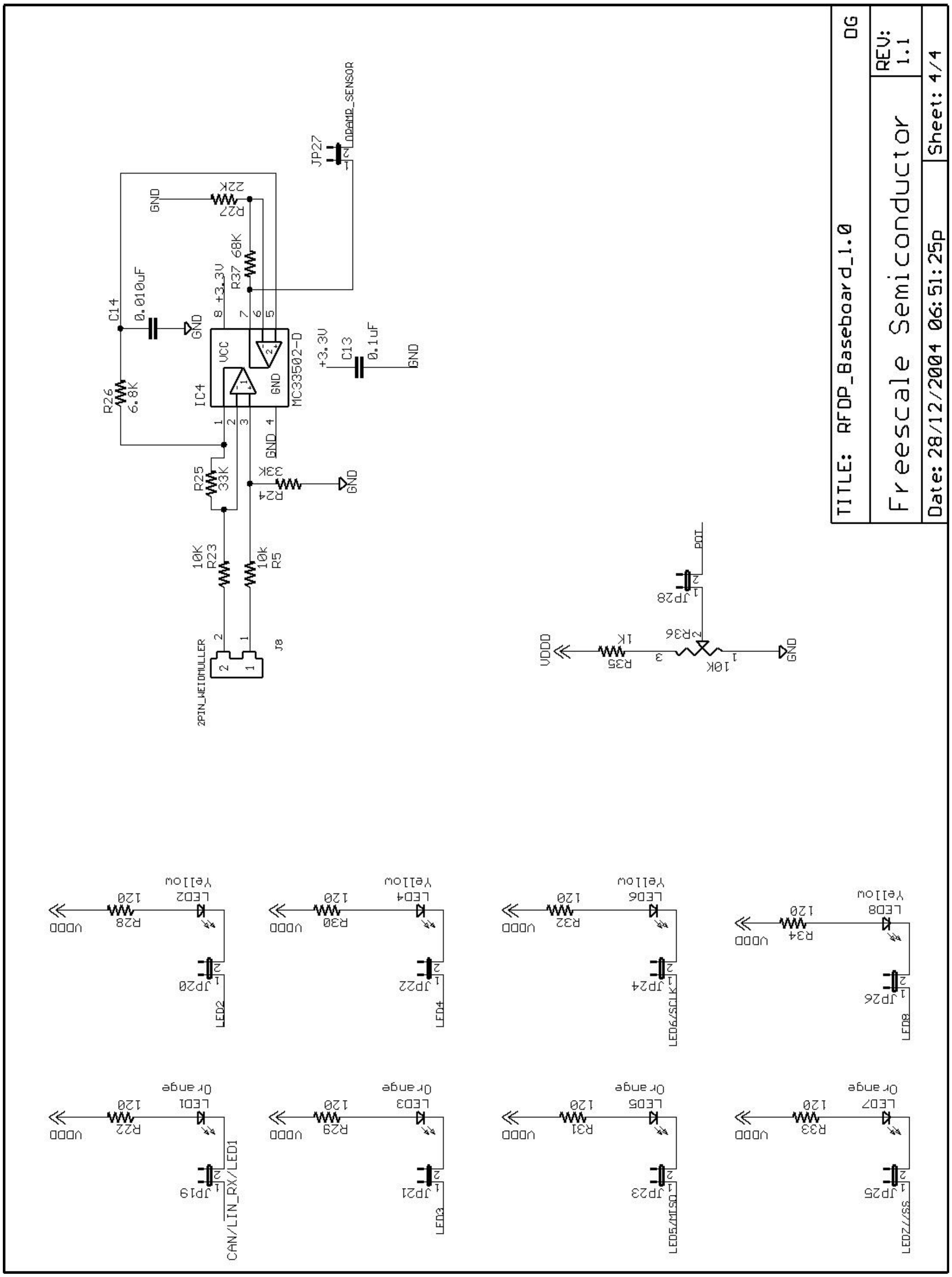


Figure 3-3. Baseboard Schematic (Sheet 4 of 4)

3.2.2 Baseboard Bill of Materials

The baseboard bill of materials is shown in

Table 3-3. Bill of Materials for the Baseboard (Sheet 1 of 2)

Item	Qty.	Designator	Description	Manufacturer	Part Number
1	1	IC1	IC Transceiver 5 V	Maxim	MAX3232E
2	1	IC2	5.0-V Regulator	National	LP8340CDT-5.0
3	1	IC3	3.3-V Regulator	National	LP8340CDT-3.3
4	1	IC4	OpAmp	On	MC33502-D
5	1	IC5	OptoIsolator	Fairchild	MOC3023M
6	12	R1, R5, R3, R9–R14, R15,R16, R23	10 K 1 % Resistor	Panasonic – ECG	ERJ6ENF1002V
7	4	R6, R8, R21, R35	1 K 1 % Resistor	Panasonic – ECG	ERJ6ENF1001V
8	1	R26	6.81 KΩ 1 % Resistor	Panasonic – ECG	ERJ6ENF6811V
9	1	R17	221 Ω 1 % Resistor	Panasonic – ECG	ERJ6ENF2210V
10	1	R7	15 Ω 1 % Resistor	Panasonic – ECG	ERJ6ENF15R0V
12	2	R4, R18	365 Ω 1 % Resistor	Panasonic – ECG	ERJ6ENF3650V
13	1	R19	475 Ω 1 % Resistor	Panasonic – ECG	ERJ6ENF4750V
14	1	R20	39 Ω 1 % Resistor	Panasonic – ECG	ERAS15J390V
15	8	R22, R28–R34	121 Ω 1 % Resistor	Panasonic – ECG	ERJ6ENF1210V
16	2	R24, R25	33.2 KΩ 1 % Resistor	Panasonic – ECG	ERJ6ENF3322V
17	1	R27	22.1 KΩ 1 % Resistor	Panasonic – ECG	ERJ6ENF2212V
18	1	R37	68.1 KΩ 1 % Resistor	Panasonic – ECG	ERJ6ENF6812V
19	1	R2	10 KΩ Pot	Copal Electronics	ST4TA103
20	1	R36	10 KΩ Pot	ALPHA (Taiwan)	317-2090-10K
21	1	R38	1.5K 1 % Ω	Panasonic - ECG	ERJ6ENF1501V
22	9	C1, C2, C3, C4, C5, C7, C8, C13, C15	CAP .10 µF 50 V CERAMIC X7R 0805	Kemet	C0805C104K5RACTU
23	1	C6	Cap. 470 µF, 16 V DC	Elna	RV-16V471MH10R
24	2	C9, C10	100 µF, 16V DC	Elna	RV2-16V101MS-R
25	1	C11	CAP .047 µF Ceramic		NP
26	2	C12, C14	0.01 µF 200 V	AVX	08052C103KAT2A
27	1	K1	Low Signal Relay	SUN-HOLD	RAS-0510
28	4	D1,D2, D3, D4	Standard Rectifier	Diodes Incorporated	S1AB
29	4	D5, D6, D7, D8	High Speed Switching Diode	Vishay	1N4148WS
30	1	LED9	SMT Chip LED Green	Hewlett-Packard	HSMG-C170
31	4	LED1, LED3, LED5, LED7	SMT Chip LED Orange	Hewlett-Packard	HSMD-C170
32	4	LED2, LED4, LED6, LED8	SMT Chip LED Yellow	Hewlett-Packard	HSMY-C170
33	1	B1	1A Rectifier Bridge	Vishay	DF02S
34	1	T1	16A Triac	ST	T1635-600G

Table 3-3. Bill of Materials for the Baseboard (Sheet 2 of 2)

Item	Qty.	Designator	Description	Manufacturer	Part Number
35	3	Q1, Q2, Q3	NPN General Purpose Transistor	On	BC817-40LT1
36	1	RV	Photo Cell 3 K – 20 K	Mouser Electronics	338-54C348
37	27	JP1–JP12, JP13–JP28, JP31	Header 2X1 (Male)	Samtec	TSW-102-23-S-S
38	3	JP29, JP30, JP32	Header 3X1 (Male)	Samtec	TSW-103-23-S-S
39	1	J5	Header 16X1 (LCD) (Male)	Tyco/AMP	1-534237-4
40	1	J6	Jack Power	CUI	PJ-002A
41	2	J1, J3	Header 20X2 Male	Samtec	TSW-120-23-S-D
42	2	J2, J4	Header 20X2 Female	Samtec	SSW-120-01-G-D
43	1	LCD	LCD 16X2 Characters	Lumex	LCM-S01602DTR/A
44	1	SCI1	PBC Mount Right Angle DB9 Female	Amphenol	617-C009S-AJ120
45	1	SW1	Keypad	Grayhill	96AB2-102-F
46	2	S1, S2	Switch 1P1T	ITT Industries C & K Div.	GT12MSCKETR
47	1	S3	Switch 1P2T	ITT Industries C & K Div.	GT11MSCKETR
48	1	BZ1	Buzzer	Projects Unlimited	PB-12N23P-05
49	3	J7, J8, J9	Conector Foco	Weidmuller	281-1400-ND
50	1	FH1	Fuse Holder	Shurter Inc.	0031.8222
51	1	F1	Fuse 1A	Wickmann	1971100000
52	3	TP1, TP2, TP5	GND Test Point – Black	Keystone	5001
53	2	TP3, TP6	+3.3V Test Point – Orange	Keystone	5003
54	2	TP4, TP7	+5.0V Test Point – Red	Keystone	5000
55	1	AC1	AC/AC Adapter 120VAC/7VAC@1300 mA	AULT	T41071300A000G
56	1	AC2	AC/AC Adapter 240VAC/7VAC@1140 mA	AULT	C41071140A000G
57	4		SPACER,1/4 HEX, ALUMINUM1, THREADED 4-40,.437"L	RAF ELEC	RAF 2103-440-A-7
58	8		Screws 4-40, 1/4"	Any available	Any available

Chapter 4
Hardware Design Considerations

4.1 Baseboard

4.1.1 Introduction

The baseboard is a general-purpose interface board that features keypad, LCD display, relay, TRIAC and various other I/O peripherals. It uses the standard 40-pin I/O connector concept, so MCU modules and RF modules can be plugged into it. The baseboard provides interfacing to outside world and can be configured for a range of uses. This section gives a quick explanation of each block of the entire hardware implementation.

4.1.2 LCD Interface

The baseboard has a header (J5) for connecting a HD44780-based character LCD module. This interface uses 6 I/O pins of the MCU; 4 I/O pins for data bus (D4 to D7) and 2 I/O pins for control (R/S and E). Then LCD module has to be configured to operate with a 4-bits data bus. The potentiometer R2 controls the LCD contrast. The interface has the pins for the backlight. Figure 4-1 shows the LCD hardware interface.

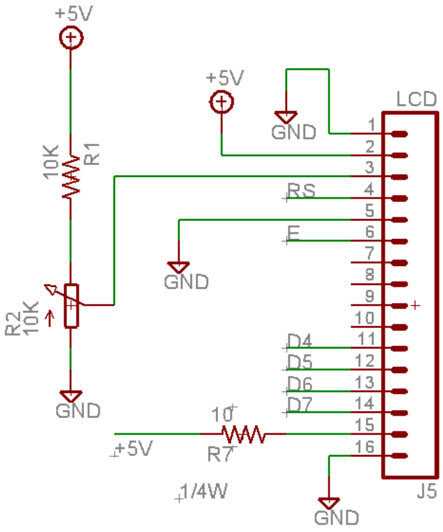


Figure 4-1. LCD Interface

4.1.3 RS-232 Interface

The baseboard provides a RS-232 interface using a MAX202 chip (IC1) referenced to V_{DDD}; this hardware allows a serial communication to the MCU. The user can select the RTS and CTS signals for a specific implementation see Figure 4-2.

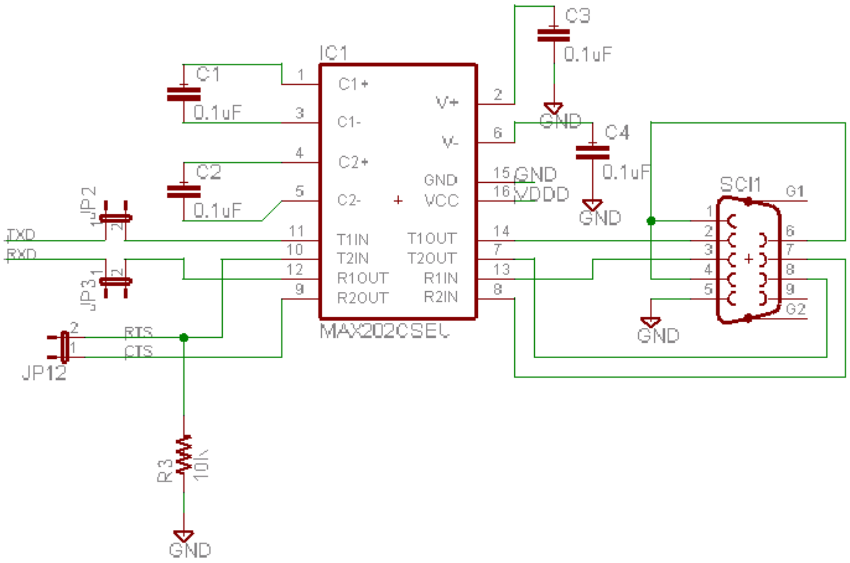


Figure 4-2. RS-232 Interface

4.1.4 3.3-V MCU 40-Pin Male Header

Header J1 of the baseboard is intended for connecting 3.3-V based MCU boards. This 40-pin connector complies with a standard concept of having a determined pin distribution of GPIOs, peripherals, power pins, etc. This standard connector is used in the MCU boards and the RF modules. For this baseboard design the specific function of each pin in this header was chosen according to the mentioned standard. The schematic of this header is shown in Figure 4-3.

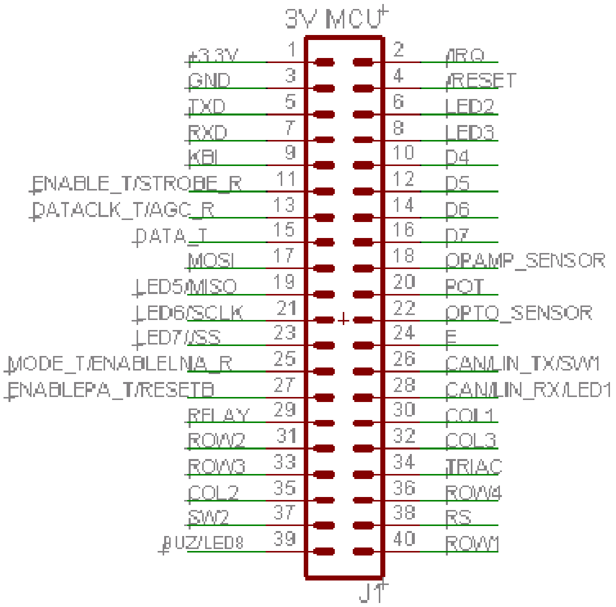


Figure 4-3. 40-Pin 3.3-V MCU Male Header

4.1.4.1 40-Pin Header Pins Description

Table 4-1 through Table 4-16 describes the function of all pins of the 40-pin header. The pins are grouped into each hardware block on the baseboard. These tables are useful for configuring the MCU pinout for the desired application.

Table 4-1. Pins Related to Tango3 (MC33493)

Pin Number	Name	Description
11	ENABLE_T	Tango standby/on control
13	DATACLK	Tango clock available for the MCU
15	DATA_T	Tango data input
25	MODE_T	Tango FSF or OOK modulation selection
27	ENABLEPA_T	Tango enable power amplifier

Table 4-2. Pins Related to Romeo2 (MC33591)

Pin Number	Name	Description
11	STROBE_R	Romeo strobe oscillator control
13	AGC_R	Romeo AGC modulation selection
17	MOSI	Romeo master out/slave in pin of SPI
19	MISO	Romeo master in/slave out pin of SPI
21	SCLK	Romeo serial clock pin of SPI
23	SS	Romeo slave select pin of SPI
25	ENABLENA_R	Romeo LNA bias control.
27	RESETB	Romeo SPI mode selection

Table 4-3. Pins Related to LCD

Pin Number	Name	Description
10	D4	Data pin for LCD interface
12	D5	Data pin for LCD interface
14	D6	Data pin for LCD interface
16	D7	Data pin for LCD interface
24	E	LCD enable pin
38	RS	Data or Instruction select pin

Table 4-4. Pins Related to SCI

Pin Number	Name	Description
5	TXD	Transmit data pin of SCI
7	RXD	Receive data pin of SCI

Table 4-5. Pin Related to TRIAC

Pin Number	Name	Description
34	TRIAC (if JP17 is enabled)	TRIAC trigger control pin

Table 4-6. Pin Related to Relay

Pin Number	Name	Description
29	RELAY (if JP18 is enabled)	Relay control pin

Table 4-7. Pin Related to Buzzer

Pin Number	Name	Description
39	BUZ (if JP13 is enabled)	Buzzer control pin

Table 4-8. Pins Related to Keypad

Pin Number	Name	Description
2	IRQ	External interrupt request pin
30	COL1	Column 1 pin
31	ROW2	Row 2 pin
32	COL3	Column 3 pin
33	ROW3	Row 3 pin
35	COL2	Column 2 pin
36	ROW4	Row 4 pin
40	ROW1	Row 1 pin

Table 4-9. Pin Related to Zero-Cross Detection Circuit

Pin Number	Name	Description
9	KBI (if JP14 is enabled)	Detects AC zero cross in falling edge pin

Table 4-10. Pin Related to Opto-Resistor Sensor

Pin Number	Name	Description
22	OPTO_SENSOR (if JP16 is enabled)	Sense light variations pin

Table 4-11. Pin Related to Signal Booster

Pin Number	Name	Description
18	OPAMP_SENSOR (if JP27 is enabled)	ADC input from signal boosting circuitry

Table 4-12. Pin Related to Potentiometer

Pin Number	Name	Description
20	POT (if JP28 is enabled)	Sense voltage variation from potentiometer pin

Table 4-13. Pins Related to LEDs

Pin Number	Name	Description
6	LED2 (if JP20 is enabled)	Yellow Led Turn on/off pin
8	LED3 (if JP21 is enabled)	Orange Led Turn on/off pin
17	MOSI (if JP31 and JP22 are enabled)	Yellow Led Turn on/off pin
19	LED5 (if JP23 is enabled)	Orange Led Turn on/off pin
21	LED6 (if JP24 is enabled)	Yellow Led Turn on/off pin
23	LED7 (if JP25 is enabled)	Orange Led Turn on/off pin
28	LED1 (if JP19 is enabled)	Orange Led Turn on/off pin
39	LED8 (if JP26 and JP32 in 1-2 position are enabled)	Yellow Led Turn on/off pin

Table 4-14. Pins Related to SPST Switches

Pin Number	Name	Description
26	SW1 (if JP15 is enabled)	Switch S1 input pin
37	SW2 (if JP1 is enabled)	Switch S2 input pin

Table 4-15. Reset Pin

Pin Number	Name	Description
4	RESET	MCU reset pin

Table 4-16. Power Pins

Pin Number	Jack Number	Name	Description
1	J1	+3.3 V	3.3-V voltage source
1	J2	+3.3 V	3.3-V voltage source
1	J3	+5 V	5-V voltage source
1	J4	+3.3 V (if JP29 is in 2–3 position) or +5 V (if JP29 is in 1–2 position)	3.3-V or 5-V voltage source
2	J1, J2, J3, J4	GND	Ground Reference

4.1.5 TANGO / ECHO 40-Pin Female Header

Header J2 is a female header intended for connecting the Tango3 RF transmitter module or any other module operating at 3.3-V and complying with the pin distribution of the 40-pin standard connector. See Figure 4-4.

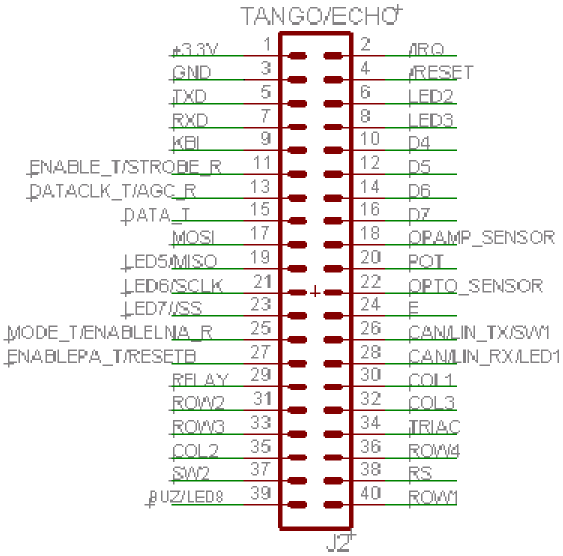


Figure 4-4. TANGO / ECHO 40-Pin Female Header

4.1.6 5-V MCU 40-Pin Male Header

Header J4 is a female header with configurable voltage pin. This voltage is selected by mean of the jumper JP29 (1–2 for 5-V) and (2–3 for 3.3-V). Then, it is possible to connect any module operating at 3.3-V or 5-V and complying with the 40-pin standard connector. This header is originally intended con connecting the Romeo2 RF receiver module. See Figure 4-5.

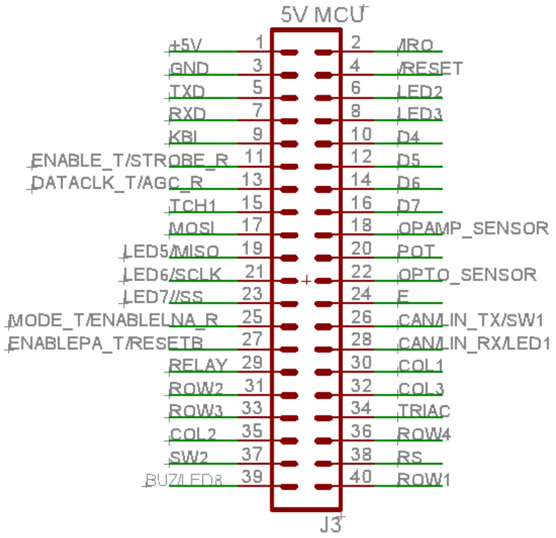


Figure 4-5. 5-V MCU 40-Pin Male Header

4.1.7 ROMEO / ECHO 40-Pin Female Header

Header J4 is a female header with configurable voltage pin. This voltage is selected by mean of the jumper JP29 (1–2 for 5-V) and (2–3 for 3.3-V). Then, it is possible to connect any module operating at 3.3-V or 5-V and complying with the 40-pin standard connector. This header is originally intended con connecting the Romeo2 RF receiver module. See Figure 4-6.

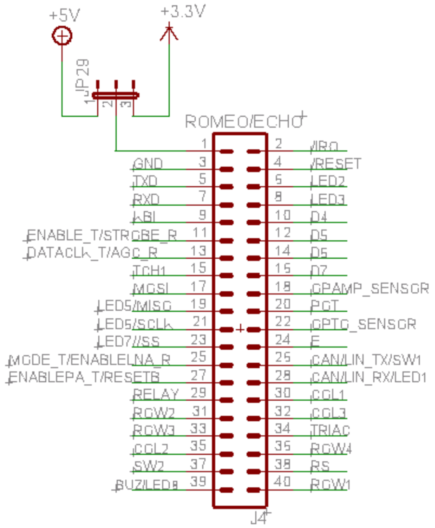


Figure 4-6. ROMEO / ECHO 40-Pin Female Header

4.1.8 Power Supply

The power input to the board is jack J5. Due to the diode bridge (B1) the input voltage can be an AC signal of typically of 7.5 VAC. The fuse (FH1) provides overcurrent protection to the board. There are two voltage regulators, one at 5-V DC and other one at 3.3-V DC. The green led (LED9) indicates the user if the 5-V power supply is working properly.

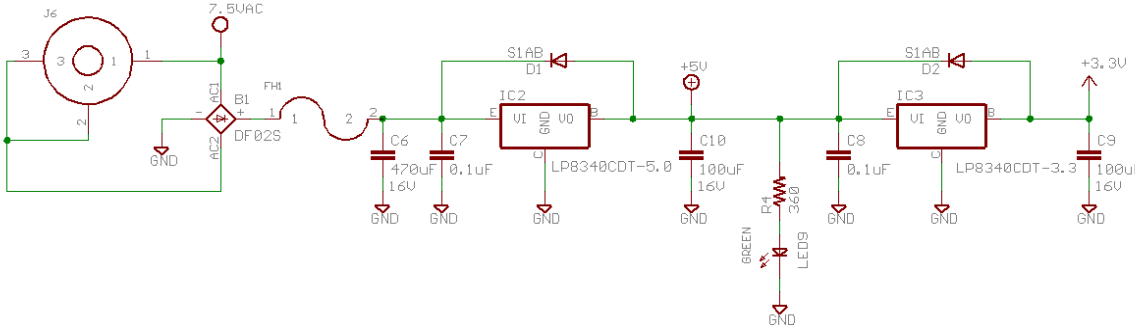


Figure 4-7. Power Supply

4.1.9 TRIAC Circuit

The baseboard includes a TRIAC (T1) controlled by the TRIAC signal when jumper JP17 is shortened. There in an opto-coupler to isolate the MCU from the AC voltage signal for protecting purposes. If the TRIAC signal is zero, the opto-coupler is activated and then it triggers the gate of the TRIAC.

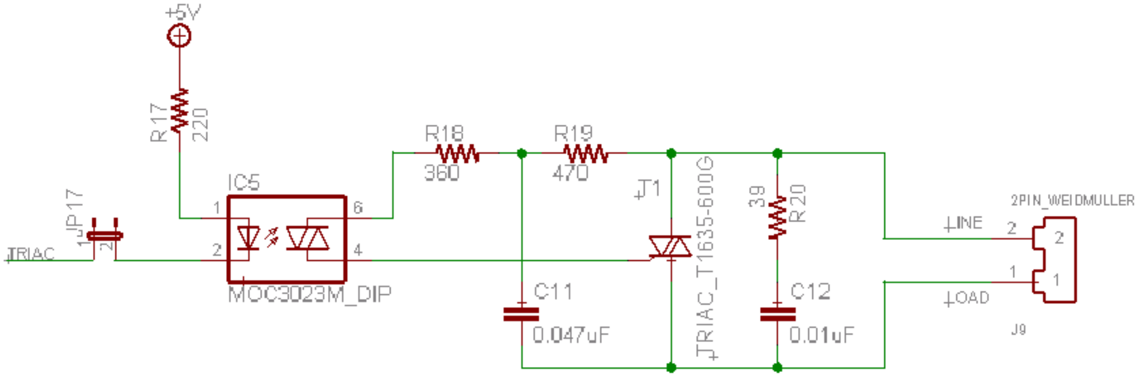


Figure 4-8. TRIAC Circuit

4.1.10 Relay Circuit

The baseboard features a relay power switch (K1). When the RELAY signal is high and the jumper JP18 is shortened, the relay closes and the load is fed with the AC line. There is a diode (D4) to protect the relay coil. See Figure 4-9.

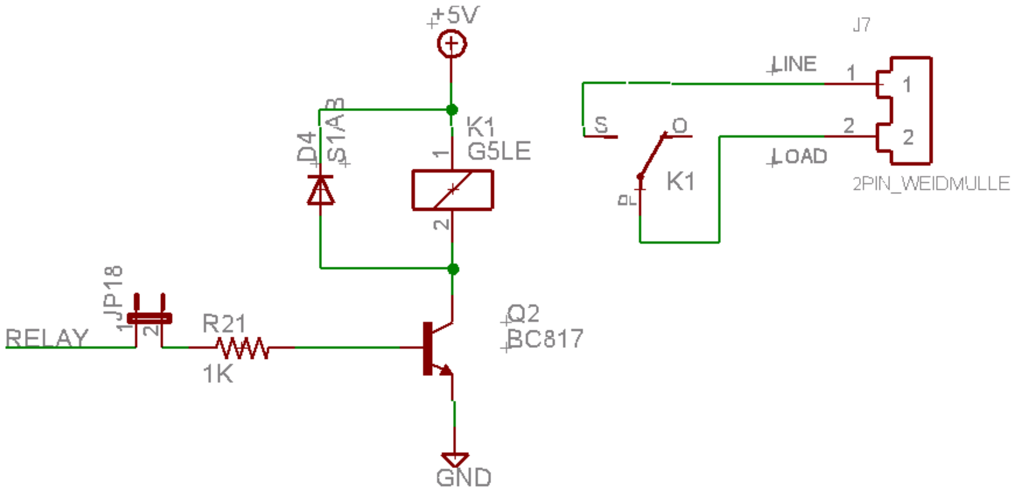


Figure 4-9. Relay Circuit

4.1.11 Buzzer Circuit

The baseboard has a buzzer (BZ1) controlled by the BUZ signal when jumper JP13 is shortened. This buzzer is driven by a NPN transistor (Q3). A square signal from the MCU is needed to generate a sound.

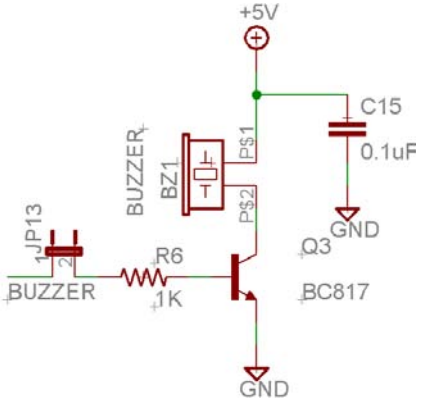


Figure 4-10. Buzzer Circuit

4.1.12 SPST Switches

There are two SPST switches into the baseboard. They can switch between GND and V_{DDD} signals. Switch S1 is connected to MCU trough signal SW1 when jumper JP15 is shortened. Switch S2 is connected to MCU trough signal SW2 when jumper JP1 is shortened..

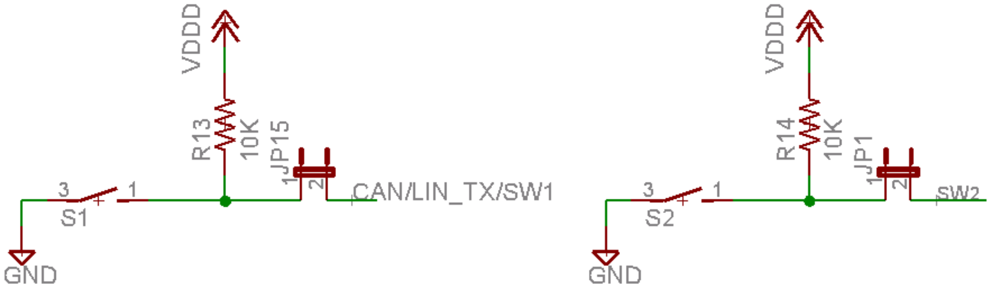


Figure 4-11. SPST Switches

4.1.13 Zero-Cross Detection Circuit

The Zero-Cross detection circuit detects when the 7.5 VAC signal crosses the zero voltage level. This event helps to synchronize the operation of the Triac when needed. This detection is done by mean of a KBI input pin of the MCU (when available) when jumper JP14 is shortened.

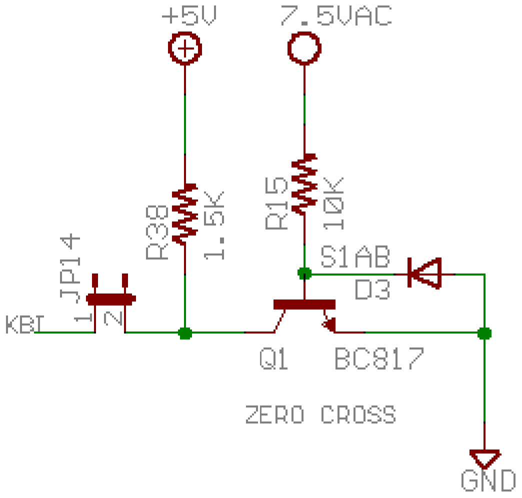


Figure 4-12. Zero-Cross Detection Circuit

4.1.14 Opto-Resistor Sensor Circuit

The baseboard has an opto-resistor sensor circuit implemented as a voltage divider between the resistor R16 and the opto-resistor RV. This circuit gives the baseboard the feature of a useful light sensor when the jumper JP16 is shortened.

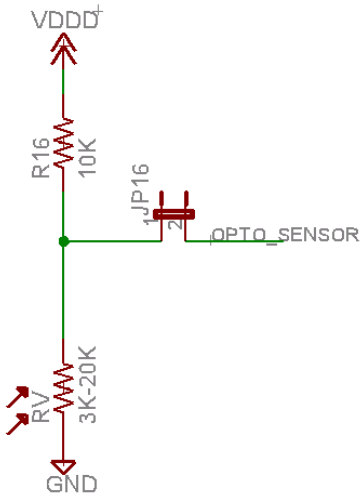


Figure 4-13. Opto-Resistor Sensor Circuit

4.1.15 Keypad Circuit

The baseboard has a 3 columns x 4 rows matrix numeric keypad. The keys are configured in a wired-or for generating an interrupt when any of them is pressed. This interrupt is driven by mean of the /IRQ signal. In this keypad circuit, the rows must be inputs to the MCU and the columns must be outputs. There is a set of jumpers that connects the columns and the rows to the MCU. See Figure 4-14.

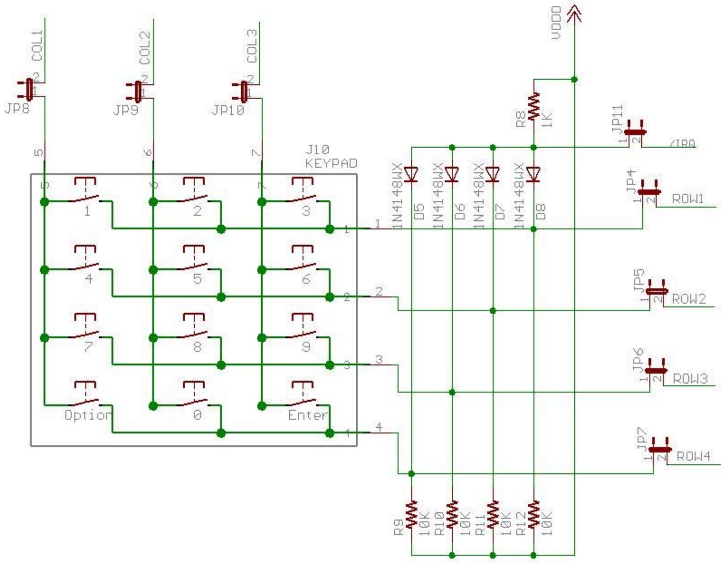


Figure 4-14. Keypad Circuit

4.1.16 LEDs Circuit

There are 8 LEDs (4 orange LEDs and 4 yellow LEDs) that can be used as a visual interface to the user. Each LED has its own enable jumper. LEDs can be turned on with a logic zero.

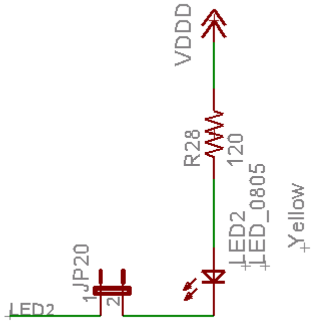


Figure 4-15. Example LED Circuit

4.1.17 Potentiometer Circuit

The potentiometer R36, in conjunction with resistor R35, makes a voltage divider. This voltage is measured trough an ADC input pin of the MCU (when available). This feature permits the user to have an analog control input. The POT signal is connected to the MCU when the jumper JP28 is shortened.

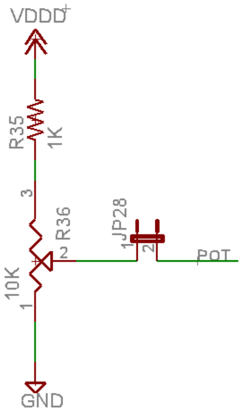


Figure 4-16. Potentiometer Circuit

4.1.18 Signal Booster Circuit

The baseboard has a signal booster circuit which has the function of amplifying a differential voltage input coming from the jack J8. This is useful for boosting the signal coming from an external sensor such a shunt resistor (current sensor). The OPAMP_SENSOR signal is connected to an ADC input pin of the MCU (when available) when the jumper JP27 is shortened.

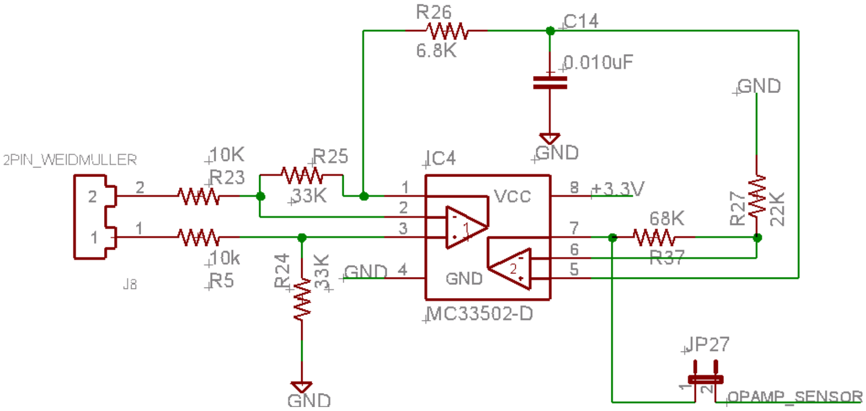


Figure 4-17. Signal Booster Circuit

4.1.19 3.3-V / 5-V Selector Switch

The baseboard has a switch to select the operating voltage for the devices referenced to V_{DDD} (for example, MAX202). This feature gives the capability to change the voltage for these devices depending on the voltage of the MCU used.

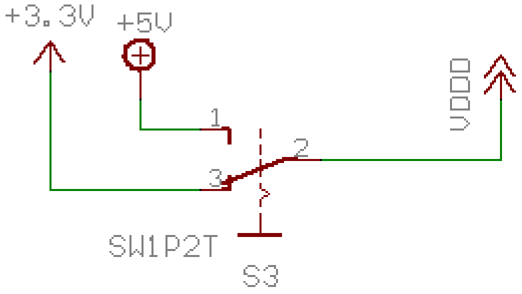


Figure 4-18. 3.3-V / 5-V Selector Switch

4.2 MC908QF4 EVB

4.2.1 Introduction

The MC908QF4EVB board was designed to have the hardware elements necessary to demonstrate the capabilities of the 908QF4 integrated circuit, and make its evaluation easy.

Therefore it includes an RS-232 and MON08 interface for programming and debugging. It also features a standard 40-pin connector to enable interfacing MCU signals with external circuitry. In addition, it has two pushbuttons, two LEDs, and one potentiometer for user interaction. For good performance a matching network exists between the RFOUT pin and the antenna. In the high-power version, the matching network is enhanced with a power amplifier.

It is important to mention that the board was not tested for government regulations compliance. The purpose of this document is to give an idea of the procedure to follow when designing with the MC908QF4 integrated circuit, but changes to the schematic will be required depending on governmental regulations.

4.2.2 RS-232 Serial Interface

The board provides an RS-232 interface to allow the user to program the microcontroller, using the MON08 interface, and to communicate via the RS-232 interface when operating in run mode. For diode D2, a Schottky diode was used because the voltage drop in a regular diode would place the logic levels near threshold. Configuration jumpers have been omitted for simplicity, and the connections shown assume the required jumpers have been placed. See Figure 4-19.

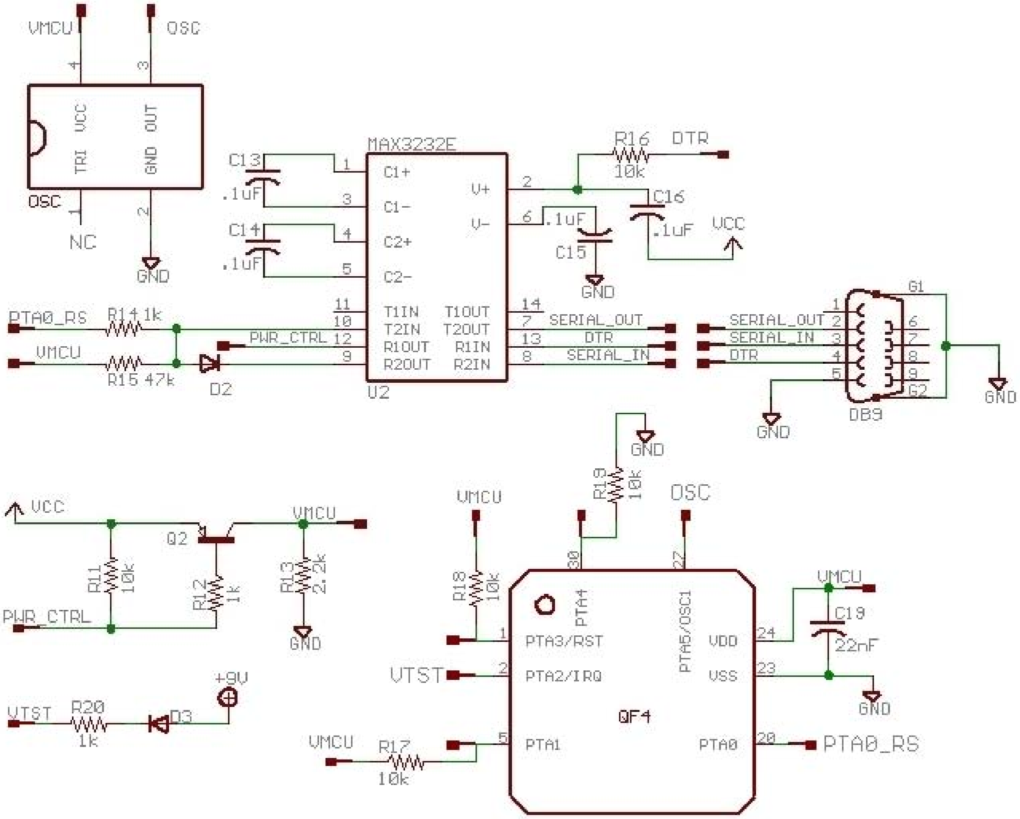


Figure 4-19. RS-232 Serial Interface

4.2.3 MON08 Multilink Hardware Interface

The user can also program and debug the microcontroller through the use of the MON08 multilink interface. Configuration jumpers have been omitted for simplicity, and the connections shown assume the required jumpers have been placed. See Figure 4-20.

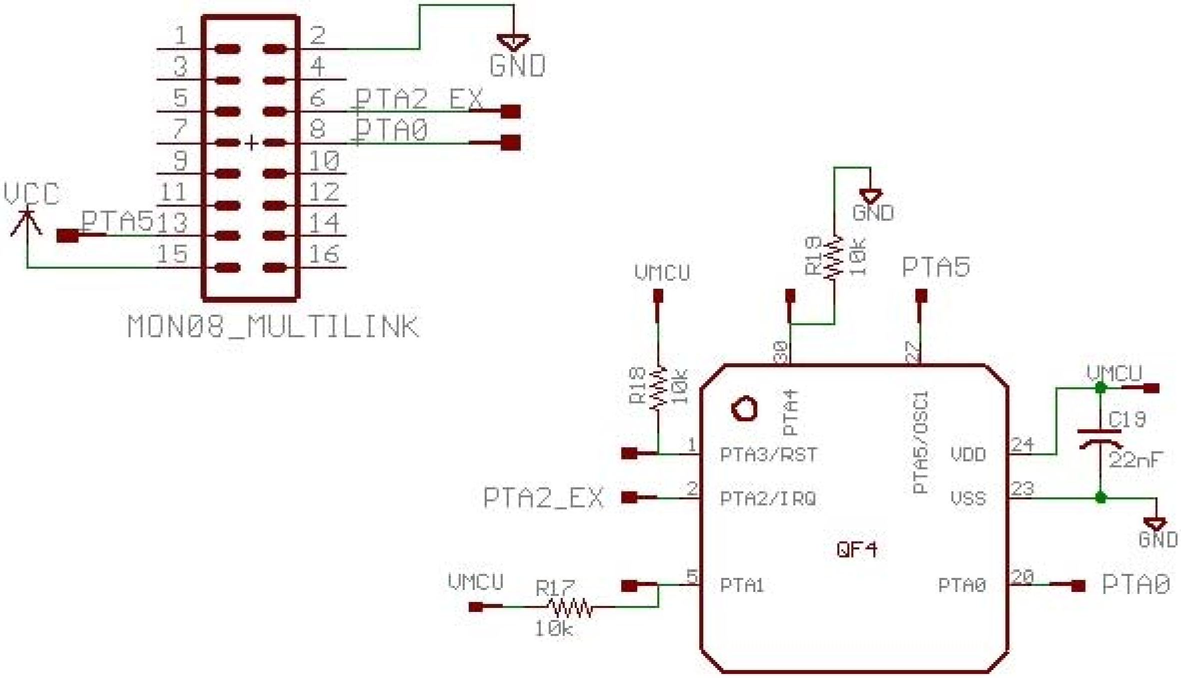
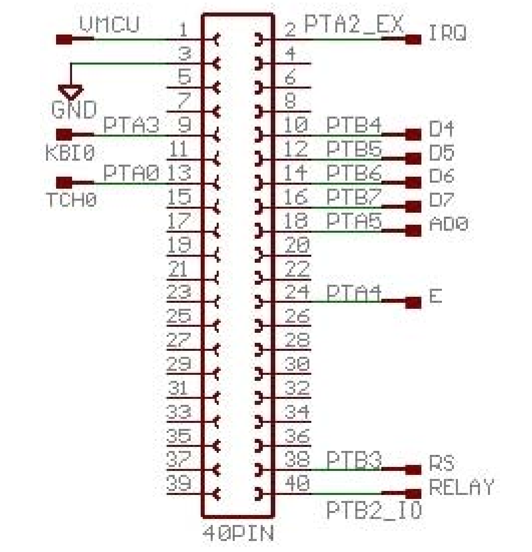


Figure 4-20. MON08 Multilink Hardware Interface

4.2.4 40-Pin Connector

Table 4-17. 40-Pin Connector Connections

PIN Number	PIN Connection	
1	VMCU	
2	If J10 is placed, this pin connects to PTA2	
3	GND	
9	PTA3	
10	PTB4	
12	PTB5	
13	PTA0	
14	PTB6	
16	PTB7	
18	PTA5	
24	PTA4	
38	PTB3	
40	If J8 is placed, this pin connects to PTB2	

4.2.5 RF Section, Low-Power Version

The board has a matching and filtering network between the RFOUT pin of the QF4 and the antenna. Its purpose is to match the 50-Ω antenna impedance to the RFOUT pin, eliminating the reactive part of the RFOUT impedance. The matching network is also used to fix the output power level. It also works as a filter and helps eliminate harmonics.

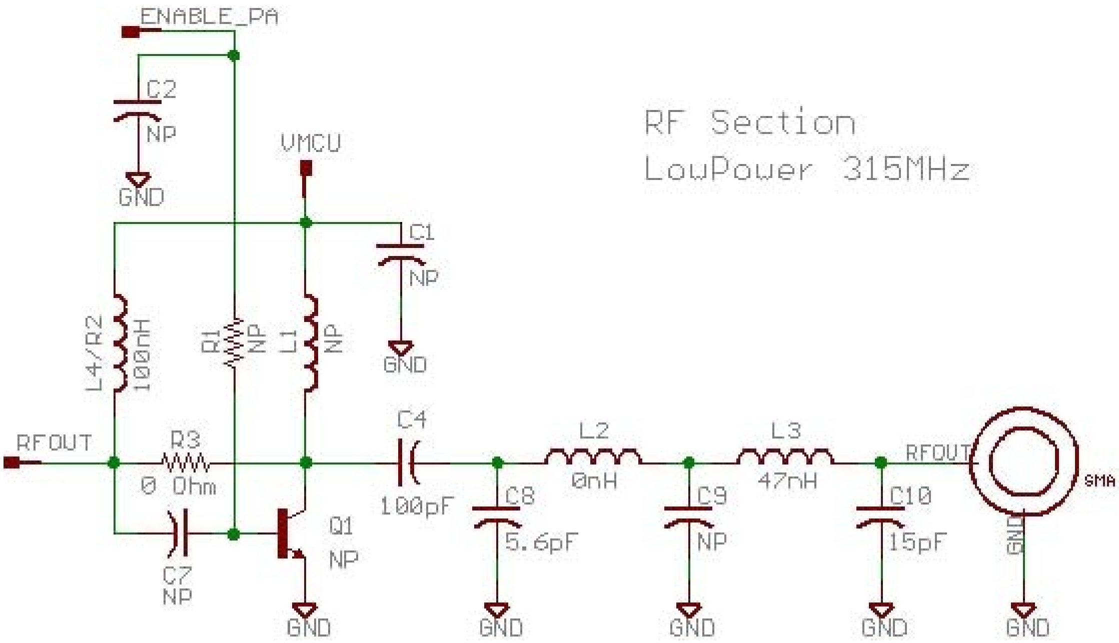


Figure 4-21. Low-Power RF Section

The output impedance of the RFOUT pin can be considered as a 250-Ω resistor in parallel with a 1.5-pF capacitor, which results in an impedance equal to:

$$Z_{FOUT} = 161.2 - 119.64\,j$$

This can be seen in the RF pin model shown in Figure 4-22. This model consists of a square wave current source in parallel with a 250-Ω resistor and a 1.5-pF capacitor.

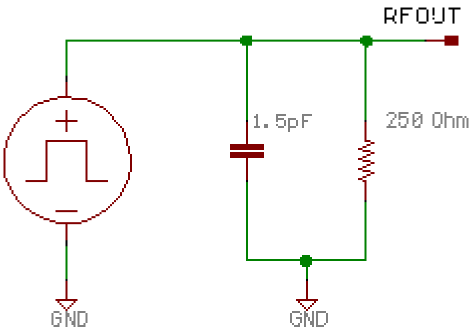


Figure 4-22. RFOUT Pin Model

The antenna impedance seen at the RFOUT pin, due to the matching network, can be calculated as follows:

$$Z_{eq} = [(((50\Omega // C_{10}) + L_3) // C_8) + C_4] // L_4$$
$$Z_{eq} = 46.43 + 112.7\,j$$

If we assume 0.1 pF stray capacitance is added to the capacitors, then:

$$Z_{eq} = 48.15 + 115.2\,j$$

Therefore, we see that stray capacitance will make Z_{eq} approach 50 + 119 j effectively canceling the reactive component of the Z_{RFOUT} impedance.

Since the output stage is a single-ended square wave switched current source, we need to know the output current to calculate the output power. From the MC68HC908QF4 data sheet we find (in Figure 17-14) that for R_{ext} = 15 k the output power, when matched, is approximately 3.5 dBm. With that information we can determine the output current.

$$Output\ Current = \sqrt{\frac{10^{3.5dBm/10}}{1000 * 161.2}}\left(\frac{161.2 + 161.2}{161.2}\right) = 7.45mA$$

It was necessary to divide by 1000 to convert milliwatts to watts. The output power can then be calculated as:

$$Output\ Power = \left[7.45mA \cdot \left(\frac{161.2\Omega}{161.2\Omega + 48.15\Omega}\right)\right]^2 \cdot 48.15\Omega = 1.58mW$$

What has been done is multiply the output current from the RFOUT pin with the current divisor formed by the RFOUT output resistance in parallel with the antenna resistance seen at the RFOUT pin. The reactive parts of the RFOUT output impedance and the antenna impedance at the RFOUT pin canceled each other; that is why we only used the real parts.

We can convert the output power to dBm:

$$\textit{Output Power} = 10 \cdot \log_{10}(Pwr_{mW}) = 10 \cdot \log_{10}(1.58\ mW) = 2\ dBm$$

The rest of the components associated with the transmitter module can be seen in Figure 4-23. Capacitors C3 and C11 are used for decoupling the power supply, to filter noise and prevent parasitic oscillations. Resistors R6 and R7 serve to hardwire the voltage level at the BAND pin, which selects the frequency of operation (GND: 868–915 MHz, V_{DD}: 315–434 MHz). The XTAL frequency is 9.84375 MHz so that the transmit frequency is:

$$f_{TX} = 9.84375\ MHz \cdot (\textit{PLL divider ratio}) = 9.84375 \cdot 32 = 315\ MHz$$

Capacitors C5 and C6 slightly modify the resonant frequency of XTAL. Suggested values can be found in the device data sheet. Capacitor C5 was omitted because parasitic capacitance on the PCB is close to the needed value. Frequency modulation is achieved when the internal switch on pin CFSK shorts capacitor C5. To avoid this process from generating spurious signals at high modulation frequencies a resistor, R4, could be included (it makes the charging of C5 less rough). Resistor R5 sets the RF output level as shown in Figure 17-14 of the MC68HC908QF4 data sheet Rev 1.0. It allows a trade-off between radiated power and current consumption.

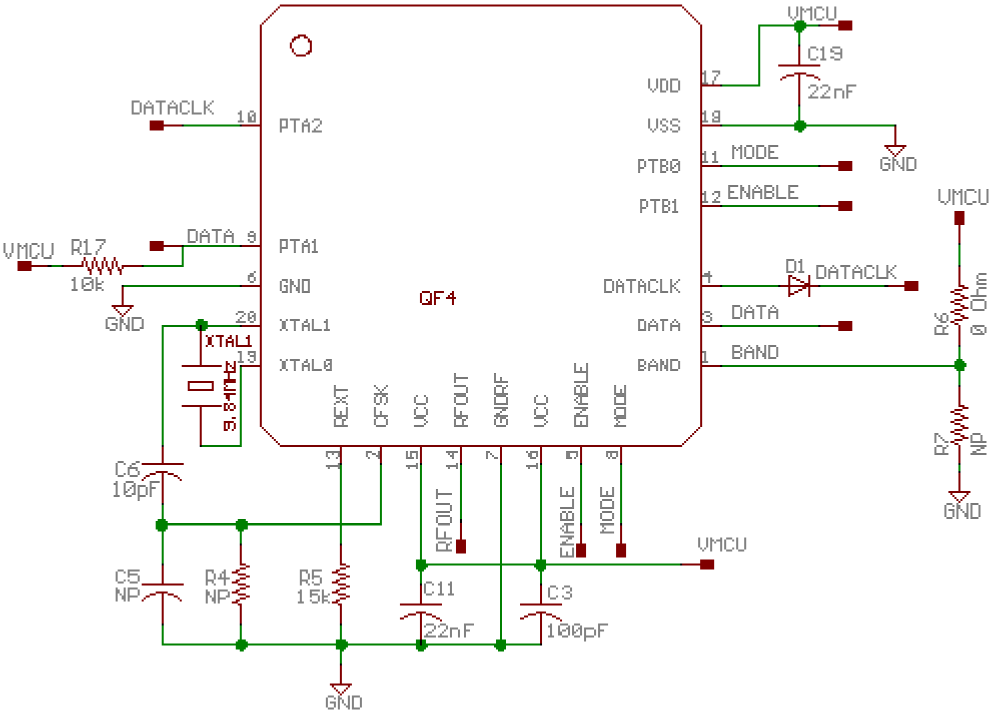


Figure 4-23. Components around MC908QF4

The I/O pin PTA1 outputs the data to be transmitted to pin DATA of the RF transmitter module of the QF4. A clock signal (DATACLK) from the transmitter module provides the microcontroller a reference frequency for data clocking. This frequency is equal to the crystal oscillator frequency divided by 64. A diode was used to protect the DATACLK pin from the high voltage applied to PTA2/IRQ when being programmed (a jumper could have been used as well). A Schottky diode was used because the voltage drop in a regular diode would place the logic levels near threshold, and a high-speed diode is preferred because the DATACLK signal is in the hundredths of kilohertz range.

PTB0 controls the MODE pin of the transmitter module. A low-logic level selects OOK modulation, and a high-logic level selects FSK modulation. PTB1 controls the ENABLE pin of the transmitter module. A low-logic level places the transmitter module in a standby mode, while a high-logic level enables the PLL and initiates the process to place the transmitter module in the ready-to-transmit state.

4.2.6 RF Section, High-Power Version[1]

In the high-power version of the MC908QF4EVB board, the RF output stage includes an RF power amplifier to boost the signal before it is fed to the antenna.

Capacitors C1 and C2 are bypass capacitors to avoid noise from the power supply and ENABLE_PA pin from coupling to the amplifier circuit. C1 also works as a decoupling capacitor for the load of the transistor. Resistor R1 biases the base of the transistor with approximately 250 µA when ENABLE_PA is a logic high.

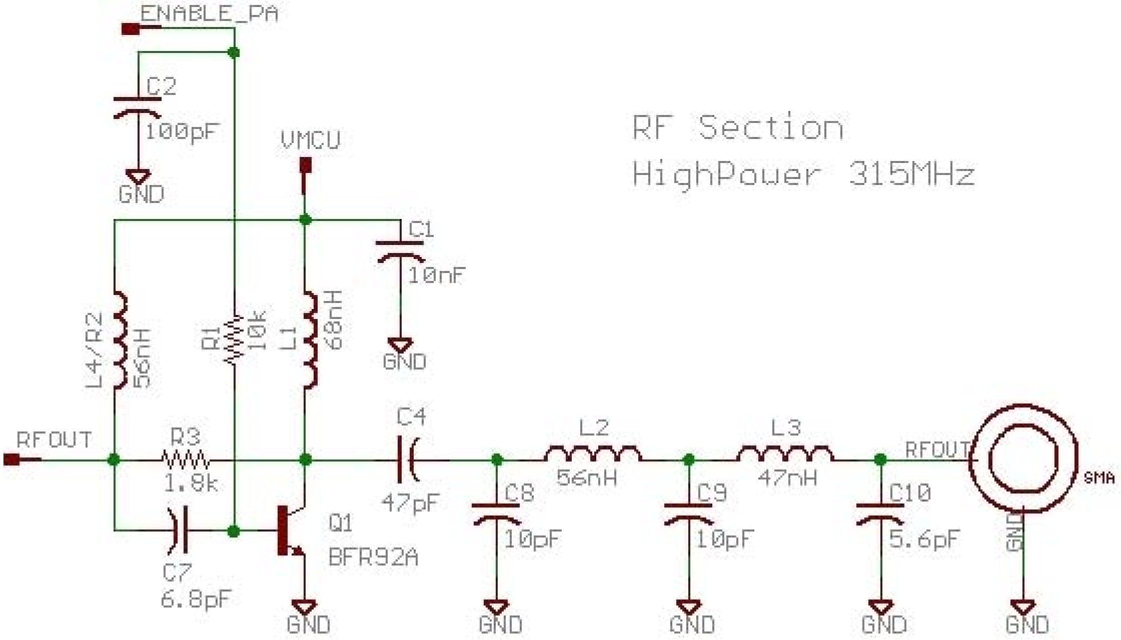


Figure 4-24. High-Power RF Section

The power amplifier is designed to work as a C-class amplifier to attain maximum efficiency. Therefore, the equivalent load of the transistor can be calculated as:

$$R_{Load} = \frac{(V_{CC} - V_{sat})^2}{2 \cdot \mathrm{P_{out}}}$$

Where V_{CC} and V_{sat} are in volts, P_{out} in watts, and R_{Load} in Ohms. Assuming $V_{CC} = 3.3$ V, $V_{sat} = 1$ V, and target output power is equal to +13 dBm (20 mW), then:

$$R_{Load} = \frac{(3\ V - 1\ V)^2}{2 \cdot (0.020\ W)} = 100\ \Omega$$

[1] The reference used for this chapter was: GAUTHIER Laurent, “A transmitter using Tango3”, Application Note AN2719, Freescale Semiconductor, Inc., 9/2004.

A matching network is therefore needed to transform the 50 Ω antenna impedance into 100 Ω, and to filter harmonics. This matching and filtering network is made up of: C4, C8, C9, C10, L1, L2, and L3.

There is a second matching network made up of R1, C7, and L4 designed to make a conjugate match between the transistor’s input impedance and the RFOUT pin output impedance. This is required to have enough current to be able to make the transistor go into saturation.

Resistor R3 introduces negative feedback which increases stability and reduces the distortion added by the power amplifier.

It is important to mention that the design for the RF power amplifier is based on a simplified approach (if required more complex models and techniques could be used, i.e., using Hot S-parameters), and the effects of stray inductance and capacitance are not considered. For this reason, an optimization process was performed ending up with the circuit of Figure 4-24. The optimization process consisted in finding for certain components the value that lead to the best performance by trying close values to the one calculated.

In the high-power version of the MC908QF4EVB board, a strong correlation was observed between spurious emissions level and current demand from the power supply (caused by the oscillator, microcontroller, and MAX3232). To further reduce spurious emissions more power supply decoupling could be added, and/or LC filters could be included at the supply pins of the above mentioned devices.

For more information please refer to AN2719 written by Laurent Gauthier and the MC68HC908QF4 data sheet.

Chapter 5
Software Design Considerations

5.1 Introduction

This section describes the message format, encryption algorithm, and a set of software drivers for the MC33493 RF transmitter (Tango3), MC68HC908QF4 microcontroller, MC33591/2/3/4 RF receiver ICs (Romeo2), and the baseboard. This section also explains how to add these drivers to an application and describes two demos developed for showing the hardware capabilities:

1. RKE / remote sensing demo (see 5.6.1 RKE / Remote Sensing Demo)
2. Home connectivity demo (see 5.6.2 Home Connectivity Demo)

Demo software and drivers have been developed to allow a designer to either quickly develop new applications using this RF development platform with minimum effort, or add RF functionality to an existing design. Additionally, this demo offers an optional encryption algorithm which can be implemented for coding data along the RF link offering a more secure communication. The drivers are written in C programming language so that they can be easily added to any project.

5.2 Message Format

Tango3, MC68HC908QF4, and Romeo2 allow RF communications at 315 MHz, 434 MHz, 838 MHz, and 915 MHz, with data rates up to 11 kbits per second. The set of software drivers provides a simple communications protocol to allow transfer of variable length messages with up to 127 bytes of data. The drivers support creation of networks with multiple receivers and transmitters.

There are several types of message formats; using ID or tone signaling, with or without the header field. These formats are supported by software drivers. These drivers extend the message formats shown in the Romeo2 data sheet, by defining length, data and checksum for each message. Hence, a message contains preamble, ID, header, length, data, checksum, and end of message.

The preamble is a fixed format field that allows Romeo2 to determine the timing of bits on the RF link. A preamble field is required before each ID and header field. Each Romeo2 device can be assigned an 8-bit ID number. Thus, it will only receive messages with this particular ID. A Tango3 or MC68HC908QF4 transmitter can send messages with any ID. The ID field can also be used to implement tone signaling, a simplified message format where each receiver uses the same fixed ID.

The header field is a 4-bit fixed format field. It notifies Romeo2 that message data is next. The header field is fixed to '0110' in this driver implementation. When Romeo2 receives the header byte, it expects to receive the length and data fields next. It is possible to send messages with or without this field. The next byte is the length field, which denotes the size of the data field expressed in bytes. After the length byte, there is the data field; this field contains the 0–127 data bytes.

The checksum field is a byte containing a checksum of the ID and data fields. It is calculated by adding those bytes using a module 256 addition. Following the checksum field is the end-of-message field (EOM); this byte indicates the end of a message. For more information, please refer to application note AN2707.

The RF development platform uses the header detection message format. A transmitter sends the preamble and the ID fields; when the receiver detects a valid ID, it will wait to receive a header field. After the receiver gets the header, it expects to receive the length, data, and checksum fields. While the receiver is waiting for the header field it will ignore all other data. With this message format, the receiver does not pass the ID field to the MCU on the SPI interface. It passes only the length, data, and checksum fields. It is possible to send both preamble and ID multiple times. Figure 5-1 shows this type of message format.

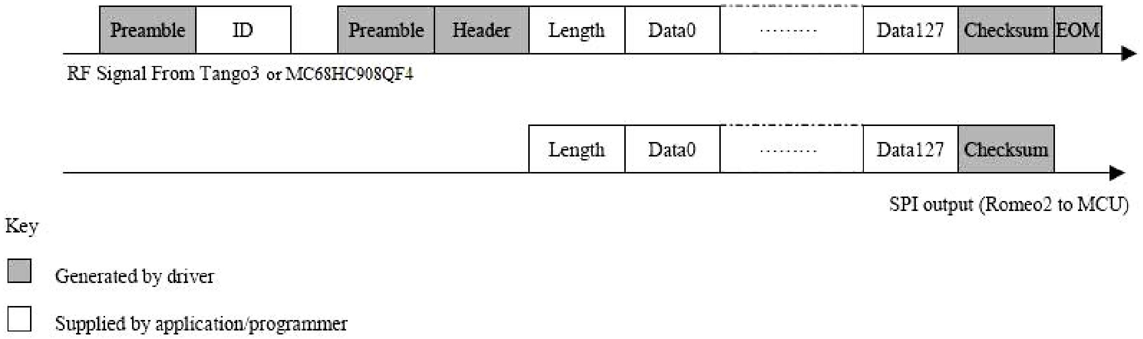


Figure 5-1. Message Format using ID and Header

5.2.1 Tango 3 Driver

Since the MC68HC908QF4 RF transmitter is very similar to Tango3 IC, the hardware connections and MCU resources used for this driver are the same. Hence, software driver structure, runtime services, and configurations are also quite similar except for names. In the following sections both the MC68HC908QF4 RF transmitter driver and Tango3 software driver will be referenced as Tango3/QF4Tx software driver.

5.2.1.1 Hardware Connections

Tango3/QF4Tx software driver uses at least two MCU terminals. There are another four optional connections between the MCU and Tango3/QF4Tx. The required hardware connections are the DATA and ENABLE lines. Figure 5-2 shows the Tango3/QF4Tx interface to the MCU.

The DATA line is used to pass the data to be transmitted to the Tango3/QF4Tx. This data is encoded using the Manchester encoding which is generated by a timer channel of the MCU. The ENABLE line enables or disables the Tango3/QF4Tx transmitter. If this line is in a high state, the Tango3/QF4Tx IC is enabled and can transmit data; when this line is in a low state, the Tango3/QF4Tx IC is disabled and placed in a low power consumption mode.

The four optional control lines are DATACLK, BAND, MODE, and ENABLEPA. The DATACLK line provides a clock signal coming from the Tango3/QF4Tx IC. This signal can be used as an accurate timebase for generating data bits for transmission.

Through the BAND line, the operating band for Tango3/QF4Tx IC is selected; defining the carrier frequency. If BAND line is set to logic 1, the RF carrier frequency is set to 32 times the Tango3/QF4Tx crystal frequency. At logic 0, the RF carrier frequency is set to 64 times the Tango3/QF4Tx crystal frequency. This line usually is hardwired to a particular value, but can also be controlled by the MCU.

The signal provided by the MODE line sets the modulation mode for Tango3/QF4Tx. FSK modulation is selected when the MODE line is at logic1. If MODE is at logic 0, OOK modulation is selected. This line can also be hardwired to a particular value, or can be controlled by the MCU.

The ENABLEPA line exists due to a power amplifier located in Freescale's Tango3/QF4Tx evaluation module and the MC68HC908QF4 Evaluation Board. This line enables or disables the additional amplifier. When ENABLEPA is at logic 1, the power amplifier is enabled; at logic 0, the power amplifier is disabled.

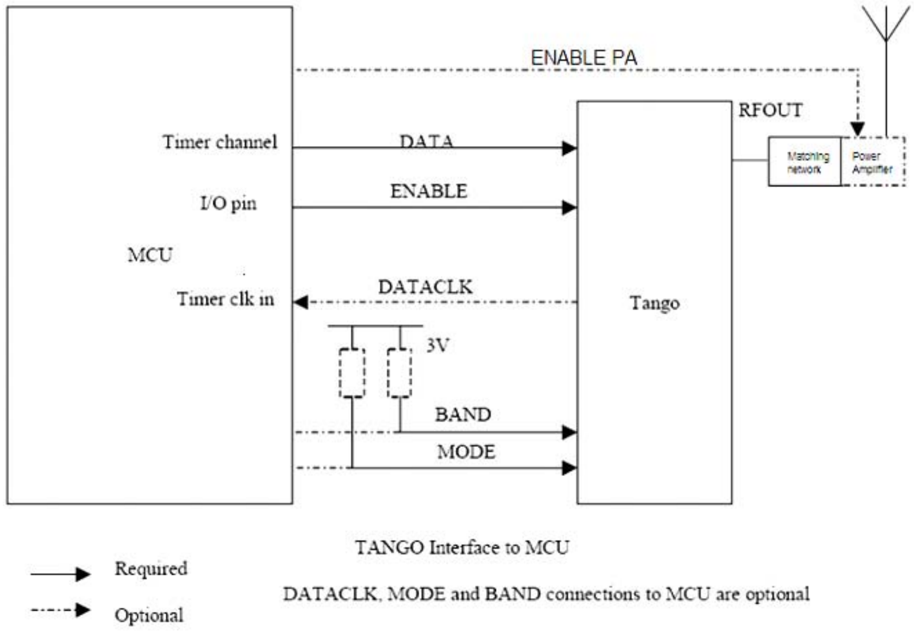


Figure 5-2. Hardware Connections

The Tango3/QF4Tx software driver requires some MCU resources. The minimum resources are one timer channel, its associated I/O pin used in output compare mode, and the interrupt vector for this timer channel. It will also require one I/O pin for controlling the ENABLE line.

There are some extra resources needed for controlling or interfacing the optional lines. One of these extra resources may be one timer channel configured as a clock input connected to Tango3/QF4Tx's DATACLCK pin. Some MCUs can select an external signal coming from a timer pin as a clock source for the timer module. Completing the extra resources are three I/O pins for controlling the MODE, BAND, and ENABLEPA lines.

5.2.1.2 Driver Services

The Tango3/QF4Tx software driver is a set of C functions that allow the user to establish the communication mode and transmit messages. Messages are constructed in a RAM buffer prior to transmission. This buffer is defined by the user, the data contained in it is read by the driver and sent over the RF link. The fields contained in the buffer are ID, length, and data. Storage for the checksum is not necessary as the driver will internally add this field to the message during transmission.

The driver is composed by two files named Tango3.h and Tango3.c. The run time services adapted for the MC68HC908QF4 RF transmitter are included in the QF4Tx.h and QF4Tx.c files.

Refer to application note AN2707 for more information.

The following functions integrate the software driver.

TangoInitialise or QF4TxInitialise

Syntax: void TangoInitialise (void); / void QF4TxInitialise (void);

Parameters: None

Return: None

Description: The TangoInitialise/QF4TxInitialise service performs initialization of the Tango3/QF4Tx IC and software driver. It does not enable the Tango3/QF4Tx IC to maintain low power consumption. It performs the following operations:

- Sets the driver status to TANGO_DISABLED/ QF4Tx_DISABLED
- Configures the MCU timer for use with Tango3/QF4Tx (Note that it does not switch the timer on)
- Configures MODE and BAND pins, if used

Notes: This service should be called before any other Tango3/QF4Tx driver services; otherwise, the result of any other Tango3/QF4Tx driver service and the Tango3/QF4Tx driver will be unpredictable.

TangoEnable or QF4TxEnable

Syntax: void TangoEnable(void); / void QF4TxEnable(void);

Parameters: None

Return: None

Description: The TangoEnable/QF4TxEnable service powers up the Tango3/QF4Tx IC and starts a 2 ms time-out count. During the timeout, the driver status is set to TANGO_IN_ENABLE_DELAY. At the end of the 2 ms timeout, the driver status is set to TANGO_READY. At this point, Tango3/QF4Tx is powered up and ready to send data.

Notes: Typically, the application will call the TangoEnable service to start up the Tango3/QF4Tx IC. During the 2 ms timeout it can load a message into the transmit buffer and call the TangoStatus service to check if the 2 ms timeout has finished. When TangoStatus returns the value TANGO_READY, the application is ready to transmit the message.

TangoDisable

Syntax: void TangoDisable(void); / void QF4TxDisable(void);

Parameters: None

Return: None

Description: The TangoDisable/QF4TxDisable service sets the driver status to TANGO_DISABLED and powers down the Tango3/QF4Tx IC. If the TANGO_TIMER_DISABLE option is chosen in the Tango.h/QF4Tx header file, the MCU timer will be switched off.

Notes: If TangoDisable/QF4TxDisable is called while a message is being transmitted, transmission will halt immediately.

TangoDriverStatus

Syntax: unsigned char TangoDriverStatus(void); / unsigned char TangoDriverStatus(void);

Parameters: None

Return:

- TANGO_DISABLED (Tango3/QF4Tx IC is powered down)
- TANGO_READY (Tango3/QF4Tx IC is powered up and ready to send data)
- TANGO_IN_ENABLE_DELAY (Tango3/QF4Tx is currently powering up and is not available to send messages)
- TANGO_BUSY (Tango3/QF4Tx is currently transmitting a message)

Description: The TangoDriverStatus service provides the application with the current status of the Tango3/QF4Tx driver.

Notes: The application must not write to the transmit buffer when status is TANGO_BUSY. Doing so will result in incorrect data being transmitted.

TangoSendPreamble_ID

Syntax: void TangoSendPreamble_ID(void);/ QF4TxSendPreamble_ID(void);

Parameters: None

Returns: None

Description: The TangoSendPreamble_ID service triggers transmission of a message containing a Preamble field and an ID field. The ID is read from the Tango3/QF4Tx transmission buffer. The driver status is set to TANGO_BUSY during transmission of this message.

Notes: This service and the TangoSendData service are used to send messages. The service should be called only when the Romeo2 RX IC is configured to detect Header bytes in a message sequence.

TangoSendData

Syntax: void TangoSendData(void);/QF4TxSendData(void);

Parameters: None

Returns: None

Description: The TangoSendData service triggers transmission of a message containing Preamble, Header, Length, Data, Checksum and EOM fields. Length and Data are read from the transmit buffer. The checksum is calculated prior to transmission.

Notes: This service and the TangoSendPreamble_ID service are used to send messages using the format described before. The service should be called only when the Romeo2 RX IC is configured to detect Header bytes in a message sequence.

TangoSendMessageNoHeader

Syntax: void TangoSendMessageNoHeader(unsigned char idRepeat)/ void QF4TxSendMessageNoHeader(unsigned char idRepeat)

Parameters: idRepeat, a specified number of times

Returns: None

Description: The TangoSendMessageNoheader service triggers transmission of a message containing Preamble, ID, Length, Data, checksum and EOM fields. The ID field is transmitted idRepeat+1 times.

Notes: This service is used to send messages using the 'No Header Detect' format described in Sending Messages without Header Detect on page 5. The service should be called only when the Romeo2 RX IC is configured to not use header.

TangoTimerInterrupt

Syntax: void TangoTimerInterrupt(void) / void QF4TxTimerInterrupt(void)

Parameters: None

Description: This function controls the actual processing of the Tango3/QF4Tx driver. It is called by the interrupt vector of the timer channel used to generate data for the Tango3/QF4Tx IC. In the CodeWarrior parameter file, this interrupt vector must be directed to this function. This function MUST be included used to ensure proper operation of the software driver.

Figure 5-3 shows the different states of the Tango3/QF4Tx driver and the values returned.

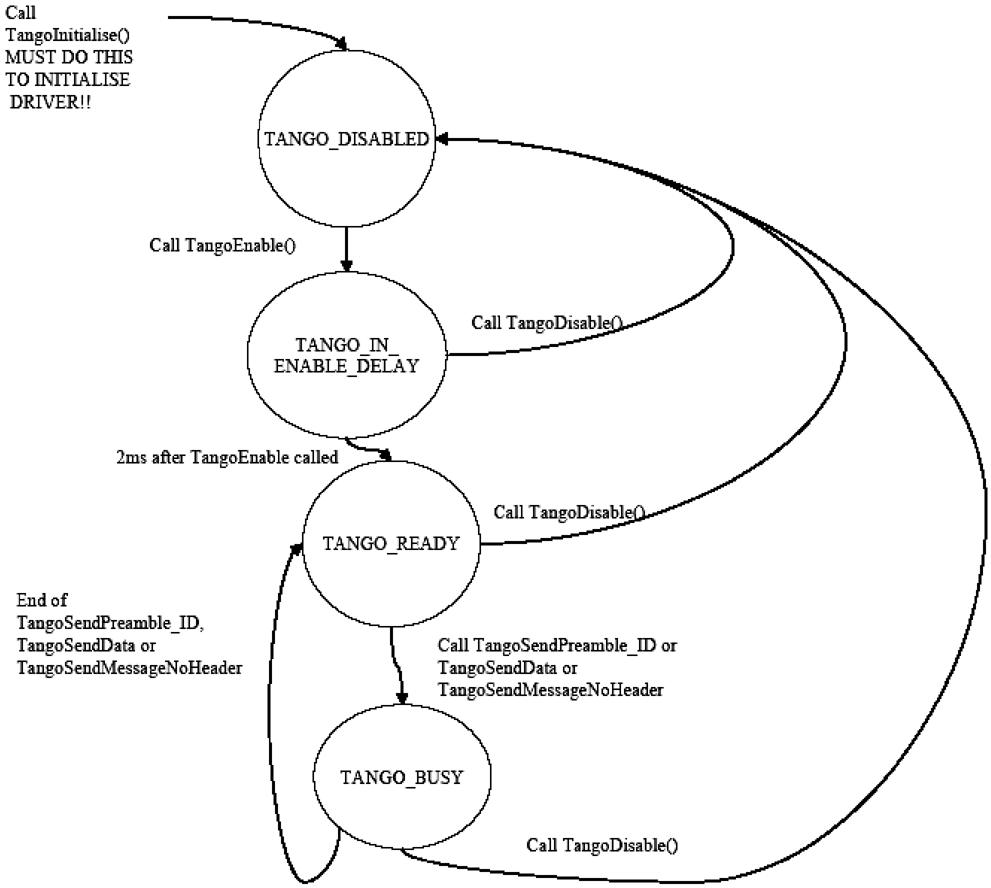


Figure 5-3. Driver States

Every time these routines are called, the driver can be in one of these four states,

1. TANGO_DISABLED
   Driver disabled, Tango3/QF4Tx IC is powered down
2. TANGO_READY
   Driver enabled, Tango3/QF4Tx IC is powered up and ready to send data
3. TANGO_IN_ENABLE_DELAY
   Driver enabled, Tango3/QF4Tx is currently powering up and is not available to send messages
4. TANGO_BUSY
   Driver enabled, Tango3/QF4Tx is currently transmitting a message

5.2.1.3 Driver Configuration

The Tango3/QF4Tx driver is statically configured at compiling time, and cannot be changed at runtime. This configurations is performed by a number of define labels located in the Tango3.h/QF4Tx.h file. Among static driver settings are,

- Message format
- Data rate
- Modulation
- Carrier frequency
- MCU optional resources

These define labels are described below.

TANGO_TIMER_ADDRESS
This defines the address of the timer status and control register, in the MCU's memory map.

TANGO_TIMER_CHANNEL
This defines the timer channel used to output data on the DATA line.

TANGO_MAX_DATA_SIZE
This defines the maximum number of data bytes that can be transferred.

TANGO_TIMER_CLOCK_SOURCE
This defines the clock used to control the timer.

TANGO_TIMER_CLOCK_SPEED
This defines the clock speed (in Hz) of the timer if an internal clock is chosen.

TANGO_TIMER_PRESCALE
This defines the prescaler value of the timer used to send data to Tango3/QF4Tx.

TANGO_TIMER_DISABLE
This allows the driver to switch off the MCU timer when it is not required to drive Tango3/QF4Tx.

TANGO_MODE_VALUE
This defines the type of modulation used in RF transmissions: OOK or FSK.

TANGO_BAND_VALUE
This defines if Tango3/QF4Tx is used in high band or low band configuration.

TANGO_CRYSTAL_FREQUENCY
This defines the speed (in Hz) of the crystal used by the Tango3/QF4Tx IC.

TANGO_DATA_RATE
This defines the data rate in bps.

TANGO_ENABLE_DDR
This defines the I/O pin used to control Tango3/QF4Tx's ENABLE pin.

TANGO_MODE
This defines the I/O pin used to control Tango3/QF4Tx's MODE pin.

TANGO_MODE_DDR
This defines the data direction bit for the I/O pin used to control Tango3/QF4Tx’s MODE pin.

TANGO_BAND
This defines the I/O pin used to control Tango3/QF4Tx's BAND pin.

TANGO_BAND_DDR
This defines the data direction bit for the I/O pin used to control Tango3/QF4Tx's BAND pin.

Figure 5-4 shows the flowchart of sending a message with header, it is the message format used in the demo software for the RF development platform.

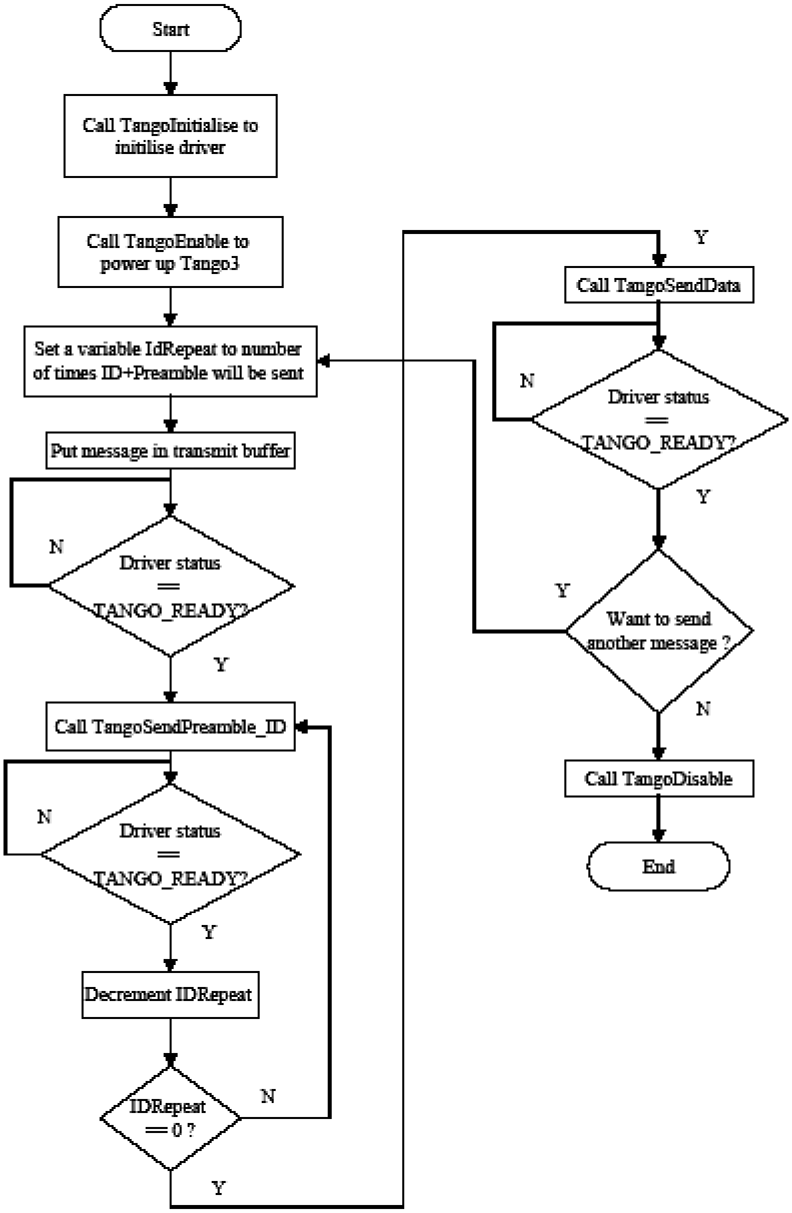

Start
Call TangoInitialise to initilise driver
Call TangoEnable to power up Tango3
Set a variable IdRepeat to number of times ID+Preamble will be sent
Put message in transmit buffer
N
Driver status == TANGO_READY?
Y
Call TangoSendPreamble_ID
N
Driver status == TANGO_READY?
Y
Decrement IDRepeat
IDRepeat ==0 ?
N
Y
Y
Call TangoSendData
N
Driver status == TANGO_READY?
Y
Y
Want to send another message ?
N
Call TangoDisable
End

Figure 5-4. Sending a Message with Header Flowchart

5.2.2 Romeo 2 Driver

This section provides a description of the Romeo2 driver application interface and run-time services.

The Romeo2 driver provides a set of runtime services using C function calls that allow the user to receive messages. The services are:

RomeoInitialise
Configure the Romeo2 driver (must be called when MCU resets)

RomeoEnable
Enables driver (and Romeo2 hardware) for reception

RomeoDisable
Disables driver (and Romeo2 hardware)

RomeoStatus
Returns current state of driver

RomeoStrobeHigh
Driver sets Romeo2's STROBE pin high

RomeoStrobeLow
Driver sets Romeo2's STROBE pin low

RomeoStrobeTriState
Driver tristates Romeo2's STROBE pin

RomeoChangeConfig
Allows driver to reconfigure Romeo2's internal registers

RomeoSPIRxInt
Provides the driver with a link to the MCU's SPI interface receive interrupt

The Romeo2 driver defines a receive buffer in RAM. The Romeo2 driver writes complete messages to this buffer after reception from the RF link. The buffer contains the message length and data fields and a buffer full status flag, as shown in Figure 5-5. The size of the buffer can be programmed by the user, using the ROMEO_MAX_DATA_SIZE parameter in the Romeo.H header file. You should make the buffer large enough to receive the largest message being transferred.

NOTE

Storage for the ID and checksum fields is not required. Each Romeo2 device has a fixed ID defined at compile time, so no additional storage is required. The Romeo2 driver calculates the Checksum field for each message internally, and compares it with the actual checksum received. If there is an error, the driver status is updated to ROMEO_CHECKSUM_ERROR.

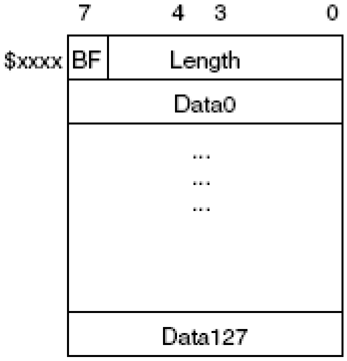


Figure 5-5. Romeo2 Receive Buffer

The Romeo2 driver can be in one of five states listed below:

1. ROMEO_DISABLED
   Driver disabled, Romeo2 IC in low-power mode.
2. ROMEO_MSG_READY
   Driver enabled, message ready in data buffer.
3. ROMEO_OVERRUN
   Driver enabled, input buffer full, previous message received has been lost.
4. ROMEO_CHECKSUM_ERROR
   Driver enabled, last message received has a checksum error.
5. ROMEO_NO_MSG
   Driver enabled, no messages waiting.

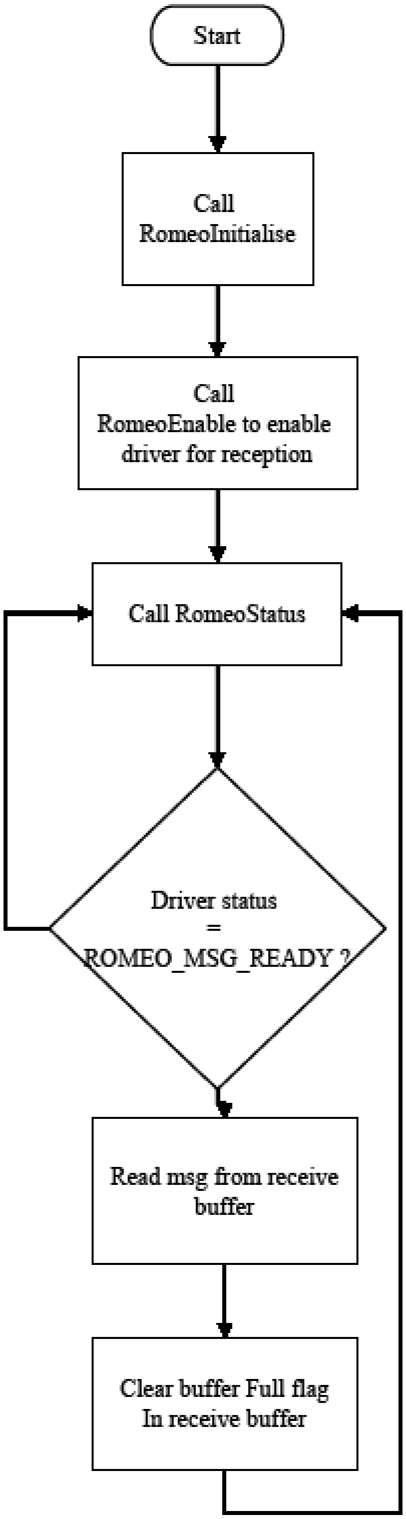

Start
Call RomeoInitialise
Call RomeoEnable to enable driver for reception
Call RomeoStatus
Driver status = ROMEO_MSG_READY ?
Read msg from receive buffer
Clear buffer Full flag In receive buffer

Figure 5-6. Configuring the Romeo2 Driver to Receive Messages

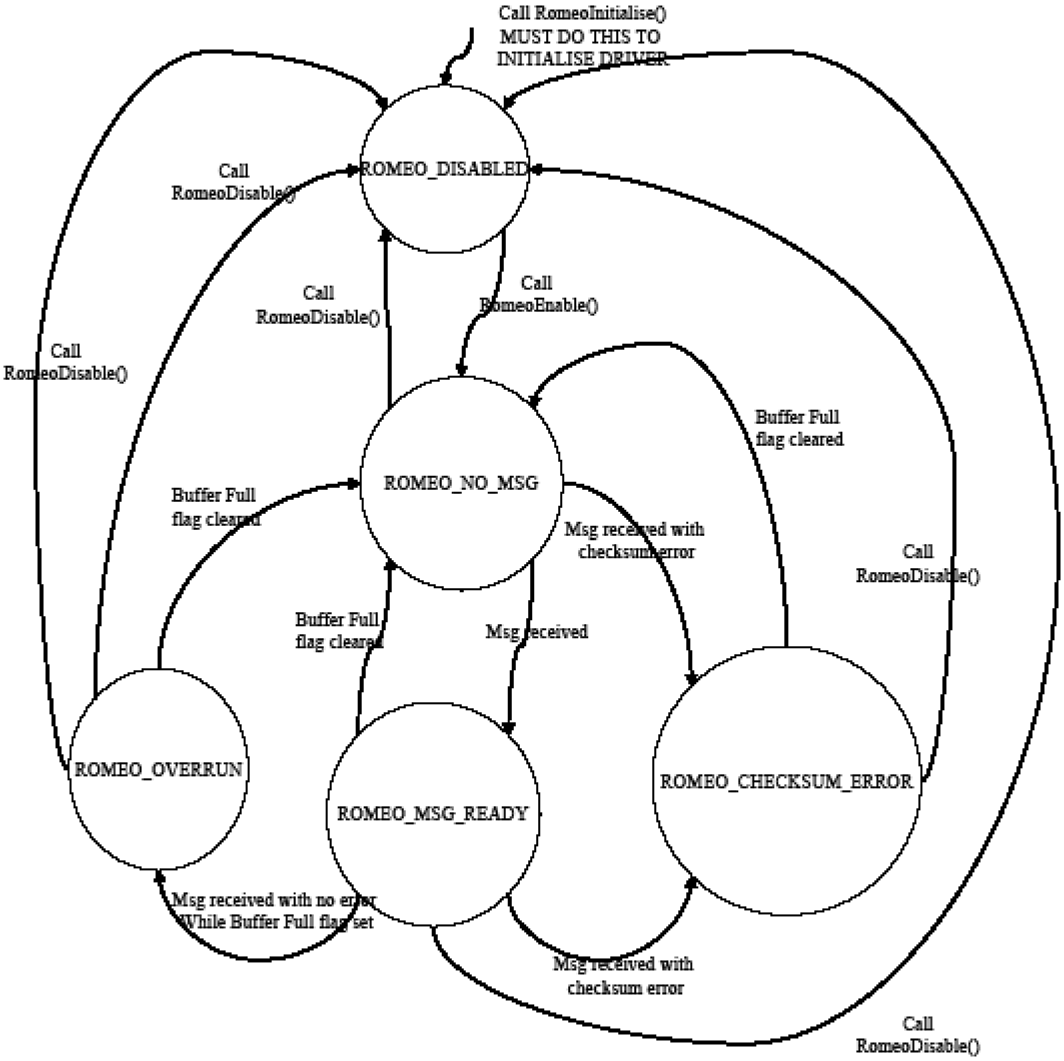


Figure 5-7. States Returned by the RomeoStatus Service

5.2.2.1 Driver Services

This section provides description of each service provided by the Romeo2 driver.

RomeoInitialise

Syntax: void RomeoInitialise(void);

Parameters: None

Return: None

Description: The RomeoInitialise service performs initialization of the Romeo2 IC and software driver. It performs the following operations.

Configures Romeo2 with options defined in Romeo.H file using SPI

Sets the driver status to ROMEO_DISABLED

Notes: This service could be called before any other Romeo2 driver services. Otherwise the result of any other Romeo2 driver service will be unpredictable.

RomeoEnable

Syntax: void RomeoEnable(void);

Parameters: None

Return: None

Description: The RomeoEnable service enables Romeo2 to receive messages. The Strobe line, if under driver control, is taken high to force Romeo2 into RUN mode. Romeo2's SPI interface is configured to make Romeo2 the master, so that it can pass data to the MCU. The driver status is set to ROMEO_NO_MSG.

RomeoStatus

Syntax: unsigned char RomeoStatus(void);

Parameters: None

Return:

- ROMEO_DISABLED — driver disabled, Romeo2 IC in low power mode
- ROMEO_MSG_READY — driver enabled, message ready in data buffer
- ROMEO_OVERRUN — driver enabled, input buffer full, previous message received has been lost
- ROMEO_CHECKSUM_ERROR — driver enabled, last message received has a checksum error
- ROMEO_NO_MSG — driver enabled, no messages waiting

Description: The RomeoStatus service returns the current state of the Romeo2 driver.

RomeoStrobeHigh

Syntax: void RomeoStrobeHigh(void);

Parameters: None

Return: None

Description: The RomeoStrobeHigh service sets the Strobe pin (if under driver control) to logic 1. This service can be called by the application to allow RUN/SLEEP mode cycling of the Romeo IC, to reduce power consumption.

RomeoStrobeLow

Syntax: void RomeoStrobeLow(void);

Parameters: None

Return: None

Description: The RomeoStrobeLow service sets the Strobe pin (if under driver control) to logic 0. This service can be called by the application to allow RUN/SLEEP mode cycling of the Romeo2 IC, to reduce power consumption.

RomeoStrobeTriState

Syntax: void RomeoStrobeTriState(void);

Parameters: None

Return: None

Description: The RomeoStrobeTriState service sets the Strobe pin (if under driver control) to a high impedance state. This service can be called by the application to allow RUN/SLEEP mode cycling of the Romeo2 IC, to reduce power consumption.

RomeoChangeConfig

Syntax: void RomeoChangeConfig(unsigned char cr1, unsigned char cr2, unsigned char cr3);

Parameters: cr1, cr2, cr3

Return: None

Description: The RomeoChangeConfig service allows the application to directly change the contents of the Romeo2 IC's internal 8-bit registers cr1, cr2 and cr3. This gives the user the option to change carrier frequency, switch on/off the strobe function, or change other functions. Please consult the Romeo2 IC data sheet for a full description of the contents of these registers.

RomeoSPIRxInt

Syntax: interrupt void RomeoSPIRxInt(void);

Parameters: None

Return: None

Description: This function is called by the interrupt vector of the SPI interface used to communicate with the Romeo2 IC. In the CodeWarrior parameter file, the SPI interrupt vector must be directed to this function. This function MUST be included to ensure proper operation of the software driver.

5.2.2.2 Romeo2 Driver Configuration

The Romeo2 driver is statically configured at compiling time. Its configuration cannot be changed at runtime. This configuration is defined in a header file “Romeo2.h”.

Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in Romeo2.h header file. These are:

ROMEO_SPI_ADDRESS
This defines the start address of the SPI control registers in the MCU's memory map.

ROMEO_MAX_DATA_SIZE
This defines the maximum number of data bytes that can be transferred.

ROMEO_RESET
This defines the I/O pin used to control Romeo2's RESET pin.

ROMEO_RESET_DDR
This defines the data direction bit for the I/O pin used to control Romeo2's RESET pin.

ROMEO_MODE_VALUE
This defines the type of modulation used in RF communication: OOK or FSK.

ROMEO_BAND_VALUE
This defines if Romeo2 is used in high band or low band configuration.

ROMEO_SOE_VALUE
This defines if the strobe oscillator is enabled on Romeo2.

ROMEO_HE_VALUE
This defines if Romeo2 uses the header detect messaging format.

ROMEO_ID_VALUE
This defines the ID word used for this particular Romeo2 IC.

ROMEO_SPI_CLOCK_SPEED
This defines the speed of the SPI clock.

ROMEO_SR_VALUE
This defines the ratio SLEEP time over RUN time for the strobe oscillator.

ROMEO_DR_VALUE
This defines the data rate of received messages before Manchester encoding.

ROMEO_MG_VALUE
This defines the gain of Romeo2's mixer stage.

ROMEO_MS_VALUE
This #define switches the position of the MIXOUT pin.

ROMEO_PG_VALUE
This define sets the gain of the phase comparator.

When starting a new project using the Romeo2 driver, you should place the file “Romeo2.h” in the project directory and a #include ‘Romeo2.h’ statement in the main application file.

5.3 TEAMAC and Driver

The TEAMAC function generates a 32-bit message authentication code from 64 bits of data and 64 bits of key. The MAC is generated using an encryption algorithm, called the Tiny Encryption Algorithm [1, 2]. This is a Feistel type algorithm which has be subjected to expert critique and is deemed to be highly resistant to cryptanalysis. Thus, it is very difficult to deduce the key from a number of valid transmissions, even if the encryption algorithm is known. The generated MAC changes unrecognizably even when only a single bit of data or key are changed. Thus, the MAC acts like a “digital signature” which is very difficult for a potential thief to generate without knowing a valid key.

The encryption function is called “TEAMAC”. The TEAMAC function encrypts the data in the global variable TEAMAC_Data with the key in the global variable TEAMAC_Key and stores the result in the global variable TEAMAC_Code.

In C code, the prototype for the function is:

```
void TEAMAC (void);
```

In C code the function is called by the instruction:

```
TEAMAC( );
```

The TEAMAC function makes use of the global variables shown in Table 5-1.

Table 5-1. Global Variables

Variable Name	Size (Bytes)	Location	Description
TEAMAC_Key	8	NVM	Contains the key for the algorithm
TEAMAC_Data	8	Zero page RAM	Contains the data to be encrypted
TEAMAC_Code	4	Zero page RAM	Contains the result (MAC) when the function returns

The key for the TEAMAC function must be stored in a global variable called TEAMAC_Key. This variable must be declared in the application as a global variable of size 8 bytes. This variable may reside at any suitable location in the HC08 memory map and is normally located in NVM. The TEAMAC function uses the key to encrypt the data and generate the MAC. In the transmitter, this variable contains a number which is usually randomly generated and programmed by the OEM manufacturer for each transmitter. In the receiver, this variable is usually programmed by the application when the receiver is in “learn” mode and has accepted the key from a valid transmitter. A receiver must store the key for each transmitter which is valid for that receiver.

The data to be encrypted by the TEAMAC function must be stored in a global variable called TEAMAC_Data. This variable must be declared in the application as a global variable of size 8 bytes and must reside in zero page RAM (address less than 0x00FF). This variable typically contains copies of the transmitter serial number and the rolling transmission counter, the command from the input switches and other system variables. If less than 8 bytes of data are used in the application, the unused bits/bytes of TEAMAC_Data must be filled with the same defined value on both transmitter and receiver.

The MAC generated by the TEAMAC function is stored in a global variable called TEAMAC_Code. This variable must be declared in the application as a global variable of size 4 bytes and must reside in zero page RAM (address less than 0x00FF).

5.4 Baseboard Drivers

5.4.1 Timebase Theory

Timebase is the solution for problems which require more timer interrupts than it had. For example: some applications may need three different timer interrupts at 3 ms, 5 ms, and 7 ms. Then, it can be created starting off with one interrupt of 1 ms or less and generating other interrupts multiple times.

5.4.2 Configuration of File “driversMaster.h”

The file “driversMaster.h” has the general configuration of all drivers used in the Reference Design.

It has three sections:

- Section one: defines the correct name of file for the peripheral declarations.

```
#ifndef MC68HC908AP64_h
    #define MC68HC908AP64_h
  #include <MC68HC908AP64.h>
#endif
```

- Section two: defines the base time used to calibrate the drivers that need it, for example LCD driver, buzzer driver, TRIAC driver, etc.

```
#define gTimeBaseInterrupteachus 200
```

  In this define specify the delay in μs used between each timer overflow interrupt. For more details read 5.4.1 Timebase Theory.

- Section three: defines which kind of MCU is being used, for example MC908 or MCS08.

```
//#define MC908
#define MCS08
```

In this section only enable the `#define` that corresponds.

5.4.3 LCD

5.4.3.1 LCD Driver Description

This section provides a description of the LCD driver application interface and run-time services.

The LCD driver provides a set of runtime services using C function calls that allow the user to show data in the LCD. The services are:

LCDInit
Configure the LCD driver (must be called when MCU reset)

LCDTimeBase
Timebase synchronization of LCD driver

LCDStatus
Returns current state of LCD driver

LCDClear
Clear display

LCD2L
Send the display cursor to the second line

LCDPrint
Print text of fixed length in the display

LCDCursor
Set the display cursor at determinate position (address)

The LCD driver uses a timebase to the configuration of the delays needed in the operation of this driver. (For more information, see 5.4.1 Timebase Theory.)

The LCD driver can be in one of six states (listed below).

1. LCD_STATUS_WAITING_INIT
   Driver disable. Default status after reset.
2. LCD_STATUS_READY
   Driver ready for instruction (LCDClear, LCD2L, LCDPrint and LCDCursor).
3. LCD_STATUS_ERROR
   Driver in error mode because it tried to send an instruction when the driver was in status different that LCDStatusReady.
4. LCD_STATUS_PRINTING
   Driver printing message.
5. LCD_STATUS_INIT
   Driver in initialization mode.
6. LCD_STATUS_WAITING
   Driver waiting for delay.

5.4.3.2 Driver Services

This section provides description of each service provided by the LCD driver

LCDInit

Syntax: void LCDInit(void);

Parameters: None

Return: None

Description: Initialize the E, RS and Data/Instructions pins of MCU connected to LCD; and configure the LCD for a standard configuration that is: 4 pin mode, 2 lines, display off, blink off, cursor off and 2x10 dots.

Notes: This service could be called before any other LCD driver services. The service that can be called before this are LCDTimeBase or LCDStatus, otherwise the result of any other LCD driver service will be unpredictable.

LCDClear

Syntax: void LCDClear(void);

Parameters: None

Return: None

Description: Clear display and sets the cursor at home position (top and left).

LCD2L

Syntax: void LCD2L(void);

Parameters: None

Return: None

Description: Set the cursor position in the second line and in the left position.

LCDPrint

Syntax: void LCDPrint(UINT8 *u8Where, UINT8 w8Length);

Parameters: *where, length

Return: None

Description: Print in the display on the actual position the characters starting off (*Where) to (*(Where+Length)).

LCDTimeBase

Syntax: void LCDTimeBase(void);

Parameters: None

Return: None

Description: Internal control for the timebase interrupts of LCD. This function must be called from the main program each time that the global variable timer LCD is equal to 0.

LCDStatus

Syntax: UINT8 LCDStatus(void);

Parameters: None

Return:

- LCD_STATUS_WAITING_INIT – Driver disable. Default status after reset.
- LCD_STATUS_READY – Driver ready for instruction (LCDClear, LCD2L, LCDPrint and LCDCursor).
- LCD_STATUS_ERROR – Driver in error mode because it tried to send an instruction when the driver was in status different that lcdStatusReady.
- LCD_STATUS_PRINTING – Driver printing message.

- LCD_STATUS_INIT – Driver in initialization mode.
- LCD_STATUS_WAITING – Driver waiting for delay.

Description: Return the current state of the LCD driver.

Notes: It is the way to inform the LCD driver to main program about the status of busy or ready of this.

In the main program this function must be used to determinate when the LCD driver is ready for a new instruction.

LCDCursor

Syntax: void LCDCursor(UINT8 u8DdramAddress);

Parameters: ddramAddress

Return: None

Description: It sets the cursor at determinate address in the LCD.

Notes: This is the configuration used: 0x00…0x0F for the first line and 0x40…0x4F for the second line.

5.4.3.3 LCD Driver Configuration

The LCD driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “driversLCD.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in driversLCD.h header file. Using these #defines, the driver can be configured to run on any MCU with six pins of GPIO.

When starting a new project using the LCD driver, you should place the files “driversLCD.h”, “driversLCD.c”, and “driversMaster.h” in the project directory and a #include ‘driversLCD.h’ statement in the main application file.

The driversLCD.h file contains a number of #define statements that must be configured to ensure correct operation of the driver. These are described below:

LCD_EXISTS

Description: This defines enable or disable the LCD functionality.

Values: None

Note: Comment this line for disable LCD functionality.

Example: `#define LCD_EXISTS`

LCD_E

Description: This defines the I/O pin used to control LCD enable signal.

Values: Any I/O pin configurable as an output can be used. Use the naming convention specified in the CodeWarrior header files.

Example: `#define LCD_E     PTA_PTA7`

LCD_E_DD

Description: This defines the data direction bit for the I/O pin used to control LCD enable signal.

Values: Any I/O pin configurable as an output can be used. Use the naming convention specified in the CodeWarrior header files.

Example: `#define LCD_E_DD     DDRA_DDRA7`

LCD_RS

Description: This defines the I/O pin used to control LCD RS signal.

Values: Any I/O pin configurable as an output can be used. Use the naming convention specified in the CodeWarrior header files.

Example:
```
#define LCD_RS     PTC_PTC7
```

LCD_RS_DD

Description: This defines the data direction bit for the I/O pin used to control LCD RS signal.

Values: Any I/O pin configurable as an output can be used. Use the naming convention specified in the CodeWarrior header files.

Example:
```
#define LCD_RS_DD     DDRC_DDRC7
```

LCD_DATA

Description: This defines the port with four I/O pins used to control LCD data/instructions signals.

Values: Any port with four I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.

Example:
```
#define LCD_DATA     PTA
```

LCD_DATA_DD

Description: This defines the data direction byte for the port with four I/O pin used to control LCD data/instructions signals.

Values: Any I/O pin configurable as an output can be used. Use the naming convention specified in the CodeWarrior header files.

Example:
```
#define LCD_DATA_DD     DDRA
```

LCD_DATA_START

Description: This defines the number of the pin in the port that start the four pins count used for LCD data/instruction signals.

Values: Number in range 0–4

Example:
```
#define LCD_DATA_START 0 /* The pins [0..3] of the port are used */
```

5.4.4 Keyboard

This section provides a description of the keyboard driver application interface and run-time services.

The keyboard driver provides a set of run-time services using C function calls that allow the user to know the pressed key. The services are listed below.

KeypadInit

Configure the keypad driver (must be called when MCU is reset)

KeypadGetKey

Returns current pressed key

The keypad driver uses an algorithm to return the ASCII code of the pressed key.

5.4.4.1 Driver Services

This section provides description of each service provided by the keypad driver

KeypadInit

Syntax: void KeypadInit(UINT8 u8UseKBI);
Parameters: u8UseKBI
Return: None
Description: Initialize the three columns, four rows, and optionally the interrupt pin (depending on the value of useKBI).
Notes: This service could be called before any other keypad driver services.
u8UseKBI = 1; enable interrupt
u8UseKBI = 0; disable interrupt

KeypadGetKey

Syntax: UINT8 KeypadGetKey(void);
Parameters: None
Return: ASCII value
Description: Returns the current ASCII value of the pressed key.

5.4.4.2 Keypad Driver Configuration

The keypad driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “diversKeypad.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in drivesKeypad.h header file. Using these #defines, the driver can be configured to run on any MCU with eight pins GPIO.

When starting a new project using the keypad driver, you should place the file “driversKeypad.h”, “driversKeypad.c”, and “driversMaster.h” in the project directory and a #include ‘driversKeypad.h’ statement In the main application file.

The driversKeypad.h file contains a number of #defines statements that must be configured to ensure correct operation of the driver. These are described below:

KEY_PAD_CONF

Description: This defines the configuration of the keypad.
Values: Array [4][3] with ASCII values
Example:

```
#define KEY_PAD_CONF
                        {'1','2','3'},
                        {'4','5','6'},
                        {'7','8','9'},
                        {'*','0','#'},
                  }
```

KEYPAD_OUT_[ONE…THREE]

Description: This defines the I/O pins used as columns of the keypad.
Values: Any I/O pins configurable as outputs can be used. Use the naming convention specified in the CodeWarrior header files.
Example:

```
#define KEY_PAD_OUT_ONE     PTD_PTD6
```

KEYPAD_OUT_[ONE…THREE]_DD

Description: This defines the data direction bit for the I/O pins used as columns of the keypad.

Values: Any I/O pins configurable as outputs can be used. Use the naming convention specified in the CodeWarrior header files.

Example: `#define KEY_PAD_OUT_ONE_DD     DDRD_DDRD6`

KEYPAD_IN_[ONE…FOUR]

Description: This defines the I/O pins used as rows of the keypad.

Values: Any I/O pins configurable as input can be used. Use the naming convention specified in the CodeWarrior header files.

Example: `#define KEY_PAD_IN_ONE     PTD_PTD4`

KEYPAD_IN_[ONE…FOUR]_DD

Description: This defines the data direction bit for the I/O pins used as rows of the keypad.

Values: Any I/O pins configurable as input can be used. Use the naming convention specified in the CodeWarrior header files.

Example: `#define KEY_PAD_IN_ONE_DD     DDRD_DDRD4`

KBI_SC

Description: This defines the KBI status and control register used for keypad interrupts.

Values: The KBI status and control registers. Use the naming convention specified in the CodeWarrior header files.

Example: `#define KBI_SC     KBSCR`

KBI_SC_FLAG

Description: This defines the bit in KBISC that correspond to the flag of KBI interrupt.

Values: Integer from 0 to 7

Example: #define KBI_SC_FLAG3

KBI_SC_ACK

Description: This defines the bit in KBISC that correspond to acknowledge of KBI interrupt.

Values: Integer from 0 to 7

Example: `#define KBI_SC_ACK     2`

KBI_SC_EN

Description: This defines the bit in KBISC that correspond to enable of KBI interrupt.

Values: Integer from 0 to 7

Example: `#define KBI_SC_EN     1`

KBI_SC_MOD

Description: This defines the bit in KBISC that correspond to edge and/or level detection of KBI interrupt.

Values: Integer from 0 to 7

Example: `#define KBI_SC_MOD     0`

KBI_[EN,EN_AD1…EN_AD7]

Description: This defines the I/O pin used for KBI interrupt.

Values: Any I/O pin configurable with KBI interrupt can be used. Use the naming convention specified in the CodeWarrior header files.

Example: #define KBI_EN   KBIER_KBIE0

5.4.5 Analogs (OpAmp, Potentiometer, Opto Sensor)

This section provides a description of the analog drivers application interface and run-time services. These analog drivers are: potentiometer, opto sensor, and signal boosting. These drivers have the same functionality and function structure.

For the remainder of this section, the analog drivers are referred to as:

- Potentiometer driver — Potentiometer
- Opto sensor driver — OptoSensor
- Signal boosting driver — OpAmp

The analog driver provides a set of runtime services using C function calls that allow the user to read an analog value. The services are:

AnalogInit
Configure the analog driver (must be called when MCU resets)

AnalogRead
Returns the current value of analog input

The analog driver uses analog inputs and returns the value converted to a digital value with precision of 8 bits.

5.4.5.1 Driver Services

This section provides description of each service provided by the analog driver.

AnalogInit
Syntax: void AnalogInit(void);
Parameters: None
Return: None
Description: Initialize and configure the ADC pin.
Notes: This service could be called before any other analog driver services.

AnalogRead
Syntax: UINT8 AnalogRead(void);
Parameters: None
Return: Integer from 0 to 255
Description: Return the digital value of an analog input.

5.4.5.2 Analog Driver Configuration

The analog driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “driversAnalog.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in driversAnalog.h header file. Using these #defines, the driver can be configured to run on any MCU with ADC module and one analog pin.

When starting a new project using analog driver, you should place the files “driversAnalog.h”, “driversAnalog.c” and “driversMaster.h” in the project directory and a #include ‘driversAnalog.h’ statement in the main application file.

The driversAnalog.h file contains a number of #define statements that must be configured to ensure correct operation of the driver. These are described below:

ANALOG

Description: This defines the I/O pin of ADC module used as analog input.
Values: Any I/O pins configurable as analog input can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define ANALOG     PTA_PTA4`

ANALOG_CHANNEL

Description: This defines the channel of ADC module associated to the pin selected in ANALOG define.
Values: Integer from 0 to 7
Example: `#define ANALOG_CHANNEL     4`

ADC_EXISTS

Description: This defines enable or disable the ADC functionality.
Values: None
Note: Comment this line for disable ADC functionality.
Example: `#define ADC_EXISTS`

ADC_SCR

Description: This defines the ADC status and control register.
Values: The ADC status and control register. Use the naming convention specified in the CodeWarrior header files.
Example: `#define ADC_SCR     ADSCR`

ADC_CLK

Description: This defines the ADC clock register.
Values: The ADC clocks register. Use the naming convention specified in the CodeWarrior header files.
Example: `#define ADC_CLK     ADICLK`

ADC_DR

Description: This defines the ADC data register.
Values: The ADC data register. Use the naming convention specified in the CodeWarrior header files.
Example: `#define ADC_DR     ADRL0`

5.4.6 Switches

This section provides a description of the Switch Driver application interface and run-time services.

The Switch Driver provides a set of runtime services using C function calls that allow the user to know the state of some switches. The services are listed below.

SwitchInit
Configure the Switch Driver (must be called when MCU reset)

SwitchStatus
Returns current status of the specific switch

5.4.6.1 Driver Services

This section provides description of each service provided by the Switch Driver

SwitchInit

Syntax: void SwitchInit(void);
Parameters: None
Return: None
Description: Initialize the relay pin.
Notes: This service could be called before any other Switch Driver services.

SwitchStatus

Syntax: UINT8 KeypadGetKey(UINT8 u8SwitchNumber);
Parameters: u8SwitchNumber
Return: Integer from 0 to 1
Description: Return the current status of the specific switch.

5.4.6.2 Switch Driver Configuration

The Switch Driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “diversSwitch.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in drivesSwitch.h header file. Using these #defines, the driver can be configured to run on any MCU with eight pins GPIO.

When starting a new project using the Switch Driver, you should place the files “driversSwitch.h”, “driversSwitch.c” and “driversMaster.h” in the project directory and a #include ‘driversSwitch.h’ statement In the main application file.

The driversSwitch.h file contains a number of #defines statements that must be configured to ensure correct operation of the driver. These are described below:

SWITCH_[ONE…TWO]

Description: This defines the I/O pins used as switches.
Values: Any I/O pins configurable as input can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define SWITCH_ONE      PTB_PTB0`

SWITCH _[ONE…TWO]_DD

Description: This defines the data direction bit for the I/O pins used as switch.
Values: Any I/O pins configurable as input can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define SWITCH_ONE_DD     DDRB_DDRB0`

SWITCH _[ONE…TWO]_PE

Description: This defines the pull enable bit for the I/O pin used as switch.
Values: Any I/O pins configurable as input can be used. Use the naming convention specified in the CodeWarrior header files.
Example: #define SWITCH_TWO_PE PTBPE_PTBPE0

5.4.7 Relay

This section provides a description of the Relay Driver application interface and run-time services.

The Relay Driver provides a set of runtime services using C function calls that allow the user to control a relay. The services are listed below.

RelayInit
Configure the Relay Driver (must be called when MCU reset)

RelayOn
Active the relay

RelayOff
Deactivate the relay

RelayToggle
Invert the status of the relay

RelayStatus
Returns current status of the relay

5.4.7.1 Driver Services

This section provides description of each service provided by the Relay Driver

RelayInit

Syntax:	void RelayInit(void);
Parameters:	None
Return:	None
Description:	Initialize the relay pin.
Notes:	This service could be called before any other Relay Driver services.

RelayOn

Syntax:	void RelayOn(void);
Parameters:	None
Return:	None
Description:	Activate the relay pin.

RelayOff

Syntax:	void RelayOff(void);
Parameters:	None
Return:	None
Description:	Deactivate the relay pin.

RelayToggle

Syntax:	void RelayInit(void);
Parameters:	None
Return:	None
Description:	Invert the current state of the relay pin.

RelayStatus

Syntax:	UINT8 KeypadGetKey(void);
Parameters:	None
Return:	Integer from 0 to 1
Description:	Return the current status of the relay pin.

5.4.7.2 Relay Driver Configuration

The Relay Driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “diversRelay.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in drivesRelay.h header file. Using these #defines, the driver can be configured to run on any MCU with eight pins GPIO.

When starting a new project using the Relay Driver, you should place the files “driversRelay.h”, “driversRelay.c” and “driversMaster.h” in the project directory and a #include ‘driversRelay.h’ statement In the main application file.

The driversRelay.h file contains a number of #defines statements that must be configured to ensure correct operation of the driver. These are described below:

RELAY

Description: This defines the I/O pins used as relay.
Values: Any I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define  RELAY     PTC_PTC6`

RELAY_DD

Description: This defines the data direction bit for the I/O pins used as relay.
Values: Any I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define RELAY_DD     DDRC_DDRC6`

5.4.8 Push Button

This section provides a description of the Push Button Driver application interface and run-time services.

The Push Button Driver provides a set of runtime services using C function calls that allow the user to detect the push button pressed. The services are listed below.

PushButtonInit
Configure the Push Button Driver (must be called when MCU reset)

PushButtonStatus
Returns current status of the specific push button

5.4.8.1 Driver Services

This section provides description of each service provided by the Push Button Driver

PushButtonInit

Syntax: void PushButtonInit(UINT8 u8useKBI);
Parameters: u8useKBI
Return: None
Description: Initialize the push buttons pins (depend the value of the useKBI).
Notes: This service could be called before any other Push Button Driver services.
u8UseKBI = 1; enable interrupt
u8UseKBI = 0; disable interrupt

PushButtonStatus

Syntax: UINT8 KeypadGetKey(UINT8 u8pushButtonNumber);
Parameters: u8pushButtonNumber
Return: Integer from 0 to 1
Description: Return the current status of the specific push button pin.

5.4.8.2 Push Button Driver Configuration

The Push Button Driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “diversPushButton.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in drivesPushButton.h header file. Using these #defines, the driver can be configured to run on any MCU with eight pins GPIO.

When starting a new project using the Push Button Driver, you should place the files “driversPushButton.h”, “driversPushButton.c” and “driversMaster.h” in the project directory and a #include ‘driversPushButton.h’ statement In the main application file.

The driversPushButton.h file contains a number of #defines statements that must be configured to ensure correct operation of the driver. These are described below:

PUSH_BUTTON_[ONE…TWO]

Description: This defines the I/O pins used as push buttons.
Values: Any I/O pins configurable as input can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define PUSH_BUTTON_ONE     PTB_PTB0`

PUSH_BUTTON_[ONE…TWO]_DD

Description: This defines the data direction bit for the I/O pins used as push buttons.
Values: Any I/O pins configurable as input can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define PUSH_BUTTON_ONE_DD     DDRB_DDRB0`

PUSH_BUTTON_[ONE…TWO]_PE

Description: This defines the pull enable bit for the I/O pin used as push buttons.
Values: Any I/O pins configurable as input can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define PUSH_BUTTON_TWO_PE     PTBPE_PTBPE0`

KBI_SC

Description: This defines the KBI status and control register used for push buttons interrupts.
Values: The KBI status and control registers. Use the naming convention specified in the CodeWarrior header files.
Example: #define KBI_SC   KBSCR

KBI_SC_FLAG

Description: This defines the bit in KBISC that correspond to the flag of KBI interrupt.
Values: Integer from 0 to 7
Example: `#define KBI_SC_FLAG3`

KBI_SC_ACK

Description: This defines the bit in KBISC that correspond to acknowledge of KBI interrupt.
Values: Integer from 0 to 7
Example: `#define KBI_SC_ACK     2`

KBI_SC_EN

Description: This defines the bit in KBISC that correspond to enable of KBI interrupt.
Values: Integer from 0 to 7
Example: `#define KBI_SC_EN     1`

KBI_SC_MOD

Description: This defines the bit in KBISC that correspond to edge and/or level detection of KBI interrupt.
Values: Integer from 0 to 7
Example: `#define KBI_SC_MOD     0`

KBI_[EN,EN_AD1…EN_AD7]

Description: This defines the I/O pin used for KBI interrupt.
Values: Any I/O pin configurable with KBI interrupt can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define KBI_EN     KBIER_KBIE0`

5.4.9 LEDs

This section provides a description of the LED driver application interface and run-time services.

The LED driver provides a set of runtime services using C function calls that allow the user to control leds. The services are listed below.

LedsInit
Configure the LED driver (must be called when MCU reset)

LedOn
Turn on the specific led

LedOff
Turn off the specific led

LedToggle
Invert the status of the specific led

5.4.9.1 Driver Services

This section provides description of each service provided by the LED driver

LedsInit

Syntax: void LedsInit(void);
Parameters: u8LedNumber
Return: None
Description: Initialize the led pins.
Notes: This service could be called before any other LED driver services.

LedOn

Syntax:	void LedOn(UINT8 u8LedNumber);
Parameters:	u8LedNumber
Return:	None
Description:	Turn on the specific led.

LedOff

Syntax:	void LedOff(UINT8 u8LedNumber);
Parameters:	u8LedNumber
Return:	None
Description:	Turn off the specific led.

LedToggle

Syntax:	void LedInit(UINT8 u8LedNumber);
Parameters:	u8LedNumber
Return:	None
Description:	Invert the current state of the specific led.

5.4.9.2 LED Driver Configuration

The LED driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “diversLed.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in drivesLed.h header file. Using these #defines, the driver can be configured to run on any MCU with eight pins GPIO.

When starting a new project using the LED driver, you should place the files “driversLed.h”, “driversLed.c” and “driversMaster.h” in the project directory and a #include ‘driversLed.h’ statement In the main application file.

The driversLed.h file contains a number of #defines statements that must be configured to ensure correct operation of the driver. These are described below:

LED_[ONE…EIGHT]

Description:	This defines the I/O pins used as LEDs.
Values:	Any I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.
Example:	`#define  LED_ONE     PTB_PTB1`

LED_[ONE…EIGHT]_DD

Description:	This defines the data direction bit for the I/O pins used as LEDs.
Values:	Any I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.
Example:	`#define LED_ONE_DD     DDRB_DDRB1`

5.4.10 Buzzer

This section provides a description of the buzzer driver application interface and run-time services.

The buzzer driver provides a set of runtime services using C function calls that allow the user to control a buzzer. The services are listed below.

BuzzerInit
Configure the buzzer driver (must be called when MCU is reset)

BuzzerSoundEnable
Activate the buzzer for a period of time with a specific sound

BuzzerTimeBase
Timebase synchronization of buzzer driver

The buzzer driver uses a timebase to the configuration of the delays needed in the operation of this driver. (For more information, see 5.4.1 Timebase Theory.)

5.4.10.1 Driver Services

This section provides description of each service provided by the buzzer driver

BuzzerInit

Syntax:	void BuzzerInit(void);
Parameters:	None
Return:	None
Description:	Initialize the buzzer pin.
Notes:	This service could be called before any other buzzer driver services.

BuzzerSoundEnable

Syntax:	void BuzzerSoundEnable(UINT8 u8Buzzer, UINT16 u16Durationms);
Parameters:	u8Buzzer, u16Durationms
Return:	None
Description:	Activate the buzzer sound defined by buzzer variable during Durationms.

BuzzerTimeBase

Syntax:	void LCDTimeBase(void);
Parameters:	None
Return:	None
Description:	Internal control for the timebase interrupts of the buzzer. This function must be called from the main program each time that the global variable timerBuzzer is equal to 0.

5.4.10.2 Buzzer Driver Configuration

The buzzer driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “diversBuzzer.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in drivesBuzzer.h header file. Using these #defines, the driver can be configured to run on any MCU with eight pins GPIO.

When starting a new project using the buzzer driver, you should place the files “driversBuzzer.h”, “driversBuzzer.c” and “driversMaster.h” in the project directory and a #include ‘driversBuzzer.h’ statement In the main application file.

The driversBuzzer.h file contains a number of #defines statements that must be configured to ensure correct operation of the driver. These are described below:

BUZZER

Description: This defines the I/O pin used as buzzer.
Values: Any I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define  BUZZER      PTC_PTC6`

BUZZER_DD

Description: This defines the data direction bit for the I/O pins used as buzzer.
Values: Any I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.
Example: `#define BUZZER_DD_     DDRC_DDRC6`

TIMER_LIMIT_BUZZER[1…3]

Description: This defines the standard sounds.
Values: Integer from GTIME_BASE_INTERRUPT_EACH_US to MAX[Integer]
Example: `#define TIMER_LIMIT_BUZZER1\`GTIME_BASE_INTERRUPT_PERMS

5.4.11 TRIAC

This section provides a description of the TRIAC driver application interface and run-time services.

The TRIAC driver provides a set of runtime services using C function calls that allow the user to control a TRIAC. The services are listed below.

TriacInit
Configure the TRIAC driver (must be called when MCU is reset)

TriacEnable
Enable the TRIAC

TriacDisable
Disable the TRIAC

TriacSync
Synchronization of the TRIAC with the zero cross detection

TriacLevel
Define the TRIAC level to work

TriacTimeBase
Timebase synchronization of TRIAC driver

The TRIAC driver uses a timebase to the configuration of the delays needed in the operation of this driver. (For more information, see 5.4.1 Timebase Theory.)

5.4.11.1 Section. Driver Services

This section provides description of each service provided by the TRIAC driver

TriacInit

Syntax:	void TriacInit(void);
Parameters:	None
Return:	None
Description:	Initialize the TRIAC pin.
Notes:	This service could be called before any other TRIAC driver services.

TriacEnable

Syntax:	void TriacEnable (void);
Parameters:	None
Return:	None
Description:	Enable the TRIAC.

TriacDisable

Syntax:	void TriacDisable (void);
Parameters:	None
Return:	None
Description:	Disable the TRIAC.

TriacSync

Syntax:	void TriacSync(void);
Parameters:	None
Return:	None
Description:	Synchronized the triac with the zero cross detection interrupt.
Notes:	This function must be called in the zero cross detection interrupt.

TriacLevel

Syntax:	void TriacLevel(UINT8 u8Level);
Parameters:	u8Level
Return:	None
Description:	Set the Level for TRIAC activation

TriacTimeBase

Syntax:	void LCDTimeBase(void);
Parameters:	None
Return:	None
Description:	Internal control for the timebase interrupts of the TRIAC. This function must be called from the main program each time that the global variable timerTriac is equal to 0.

5.4.11.2 TRIAC Driver Configuration

The TRIAC driver has a static configuration at compile time. Its configuration cannot be changed during run time. The driver configuration is defined in a header file “diversTriac.h”. Configuration options are available to define which MCU pins to use. These are set using a number of #define statements in drivesTriac.h header file. Using these #defines, the driver can be configured to run on any MCU with eight pins GPIO.

When starting a new project using the TRIAC driver, you should place the files “driversTriac.h”, “driversTriac.c”, and “driversMaster.h” in the project directory and a #include ‘driversTriac.h’ statement In the main application file.

The driversTriac.h file contains a number of #defines statements that must be configured to ensure correct operation of the driver. These are described below:

TIMER_LIMIT_TRIAC_ON

Description: This defines the number of timebase interrupts to wait in high state for the activation of the triac.

Values: Integer from 1 to GTIME_BASE_INTERRUPT_EACH_MS * 1

Example: `#define  TIMER_LIMIT_TRIAC_ON2`

TIMER_LIMIT_100

Description: This defines the number of timebase interrupts between each zero cross.

Values: Integer from 1 to GTIME_BASE_INTERRUPT_PERMS * 8.3

Example:

```
#define TIMER_LIMIT_100 \
((unsigned long)(GTIME_BASE_INTERRUPT_PERMS * 7)+8)
```

TRIAC

Description: This defines the I/O pin used as TRIAC.

Values: Any I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.

Example: `#define  TRIAC     PTB_PTB6`

TRIAC_DD

Description: This defines the data direction bit for the I/O pins used as triac.

Values: Any I/O pins configurable as output can be used. Use the naming convention specified in the CodeWarrior header files.

Example: `#define TRIAC_DD     DDRB_DDRB6`

5.5 Adding Drivers to an Application

5.5.1 TANGO/QF4Tx

To add Tango3/QF4Tx driver to the demo software, the following action items must be performed.

- Adding Tango.h/QF4Tx.h and Tango.c/QF4Tx.c files to the project.
- Including Tango.h/QF4Tx.h file to the main program using #include statement
- Declaring the TangoTransmitBuffer[]/QF4TxTransmitBuffer[] as external unsigned character, this must be done in the main application program file
- Defining the I/O pins used to control Tango3/QF4Tx or MC68HC908QF4 RF transmitter functions.
- Defining the timer used to generate the data for Tango3/QF4Tx IC or MC68HC908QF4 RF transmitter
- Modifying project parameter file (.prm file) to link timer channel interrupt vector to TangoTimerInterrupt/QF4TxTimerInterrupt routine.
- Modifying Tango.h/QF4Tx.h file to define the static driver settings.

5.6 Demo Software

There are two software programs for demonstrating some capabilities and features of the RF development platform, these demo programs are RKE / Remote Sensing Demo and Home Connectivity Demo.

5.6.1 RKE / Remote Sensing Demo

The system has at least two transmitters, one using the MC68HC908QF4, the other one using an MC9S08RG60 MCU module with the Tango3 RF module and baseboard. The QF4 transmitter can send simple ‘open/close’ commands that can control the relay and display some text on LCD; it can also take ‘analog’ input from a potentiometer and send it to receiver when values need to be updated. The second transmitter can also send ‘Open/Close’ commands and the value of a key pressed on the keypad. This demo is shown in Figure 5-8.

The receiver has a baseboard with AP64 MCU and Romeo2 boards attached. Messages from transmitters to the receiver are sent using software drivers with the TEAMAC encryption code running on top. This software demo is compound by two layers, the high and low levels.

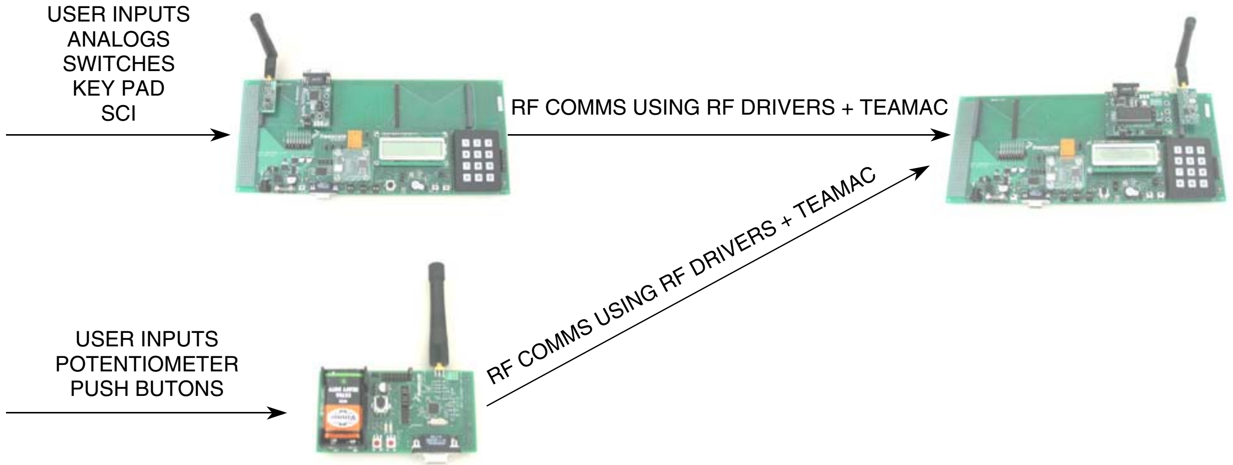


Figure 5-8. RKE / Remote Sensing Demo

The QF4 transmitter software has in the high level layer two tasks; these layers are shown in Figure 5-9

1. Send Command
   This module calls Tango driver and TEMAC functions for sending certain command or data to Rx. There is an ID for both Transmitters defined by TEAMAC encryption Key which is loaded in transmitter and receiver memory. There are two possible commands, open and close relay; the sent command depends on which button has been pressed. Data is the value read from analog to digital converter.
2. Read Potentiometer
   This module calls the analog-to-digital driver functions for reading the present value on the potentiometer.

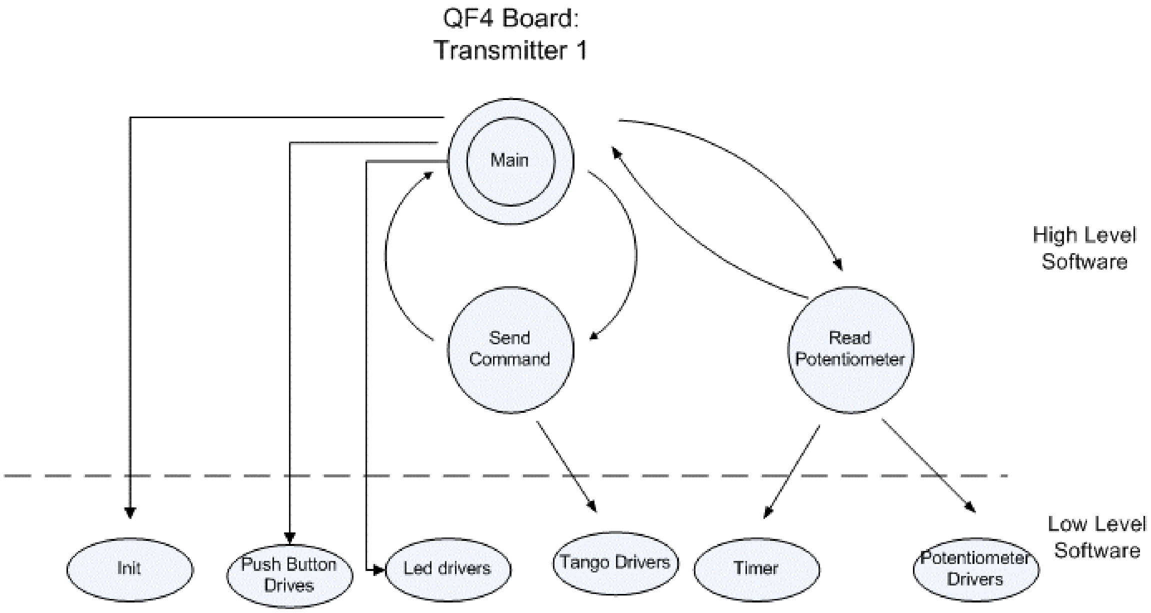


Figure 5-9. RKE / Remote Sensing Demo

Figure 5-10 shows the flowchart of the QF4 transmitter program. After power on, the first action performed by MC68HC908QF4 is configuring peripherals needed by subsequent functions. Among the settings performed by the MCU are:

- Disabling watchdog timer
- Configuring keyboard interrupt module
- Configuring two general port I/O as outputs for driving two LEDs
- Initialing and enabling QF4 transmitting module
- Enabling interrupts.

Following the configuring activity is an infinite loop, where MCU waits for 100 ms or an interrupt generated by KBI module. If a period of one hundred milliseconds occurred ADC result register is read and stored into the DATA field of the QF4TxTransmitBuffer.

If a push button was pressed then a KBI interrupt is generated and MCU executes the corresponding interrupt service routine (ISR). Inside this ISR, the pressed button is recognized and therefore a command is identified. This command is stored into the DATA field of the QF4TxTransmitBuffer.

Send command execution includes the TEAMAC algorithm, where the rolling code counter and the command number are encrypted prior to transmission. Hence, the transmit buffer contains the rolling code counter, the command number, data, and four TEAMAC code bytes.

After the MCU has sent the message, it is placed on an infinite loop waiting for either a KBI interrupt or a 100 ms delay for reading ADC.

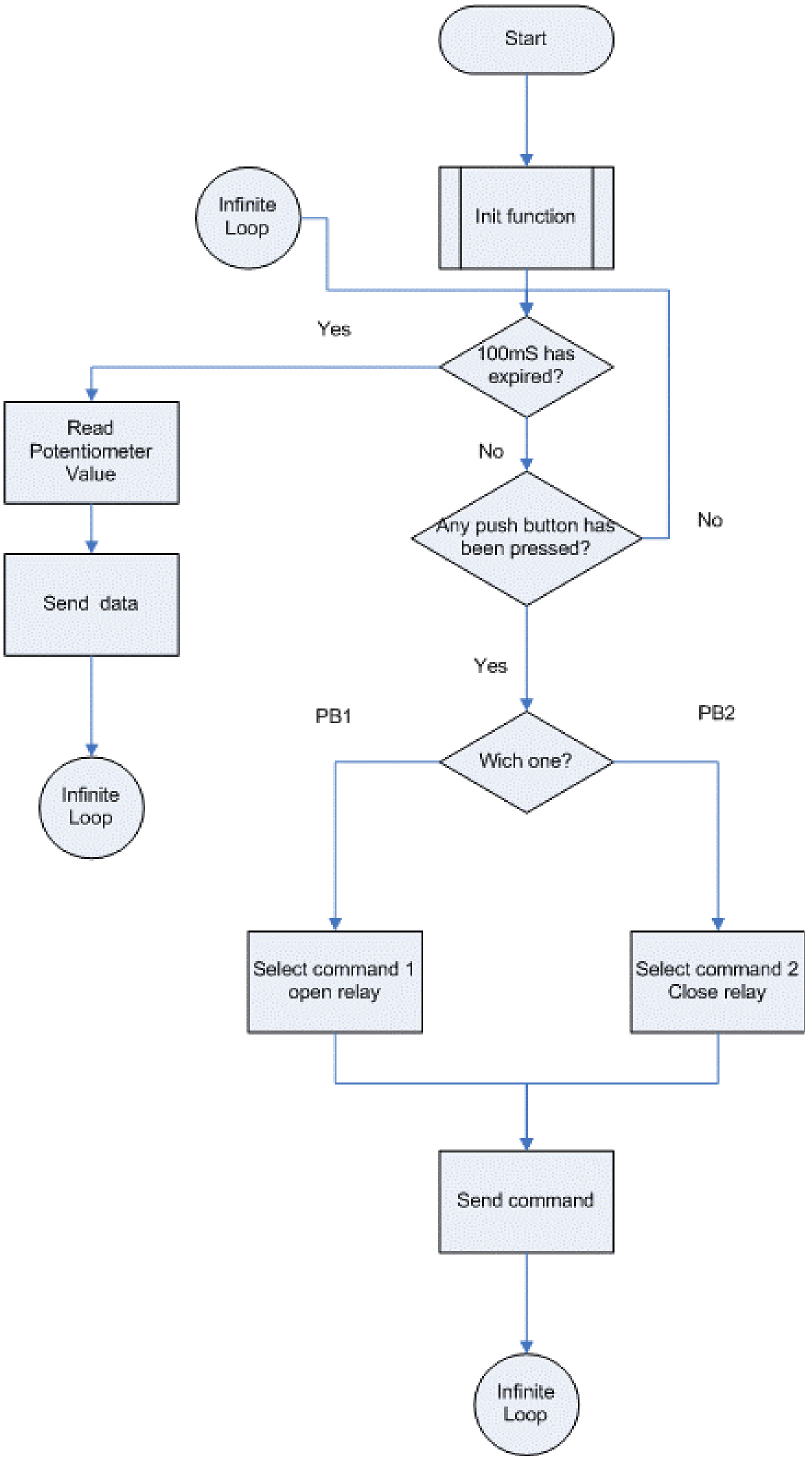


Figure 5-10. RKE / Remote Sensing Demo QF4 Transmitter Flowchart

RG60-baseboard transmitter software has in the high level layer one task shown in Figure 5-11. This task is described as:

1. Send command. This module calls Tango driver and TEMAC functions for sending certain command or data to Rx. There is an ID for both transmitters defined by TEAMAC encryption key which is loaded in transmitter and receiver memory. Commands are: open and close relay; the sent command depends on which button has been pressed.

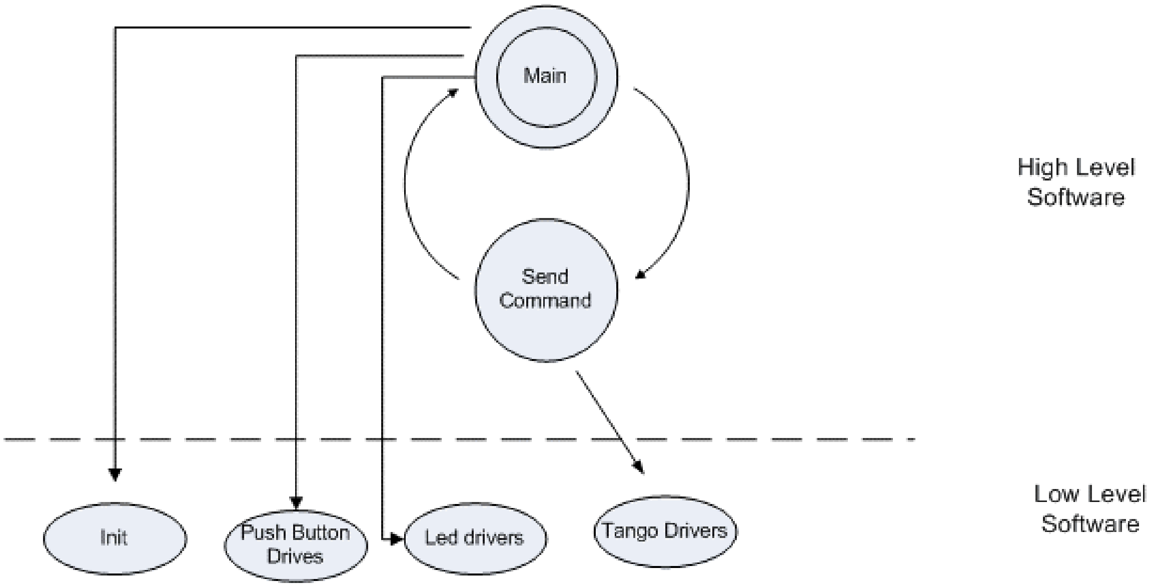


Figure 5-11. RG60 MCU and Baseboard: Transmitter 2

Figure 5-12 shows the RG60-Tango3 baseboard transmitter program flowchart. After power on, the first action performed by RG60 MCU is configuring peripherals needed by subsequent functions. Among the settings performed by the MCU are:

- Disabling watchdog timer
- Enable reset pin
- Enable debug pin
- Configuring port E6 as input for driving a switch
- Configuring ports C5, C6, and C7 as outputs for driving LEDs
- Initialing and enabling Tango3 RF module
- Enabling interrupts

Following the configuring activity is an infinite loop, where the MCU waits for a change on the switch. If the switch level was changed then the main program detects either a falling edge or a rising edge. When a falling edge has been detected, the MCU loads an ‘open’ command and on the transmit buffer; if a rising edge is detected a ‘close’ command is loaded on the transmit buffer. In both cases the rolling code counter is added. The commands and rolling code counter are part of the DATA field.

Send command execution includes the TEAMAC algorithm, where the rolling code counter and the command number are encrypted prior to transmission. Hence, the transmit buffer contains the rolling code counter, the command number, data, and four TEAMAC code bytes. After the MCU has sent the message, it is placed on an infinite loop waiting for a new level on the switch.

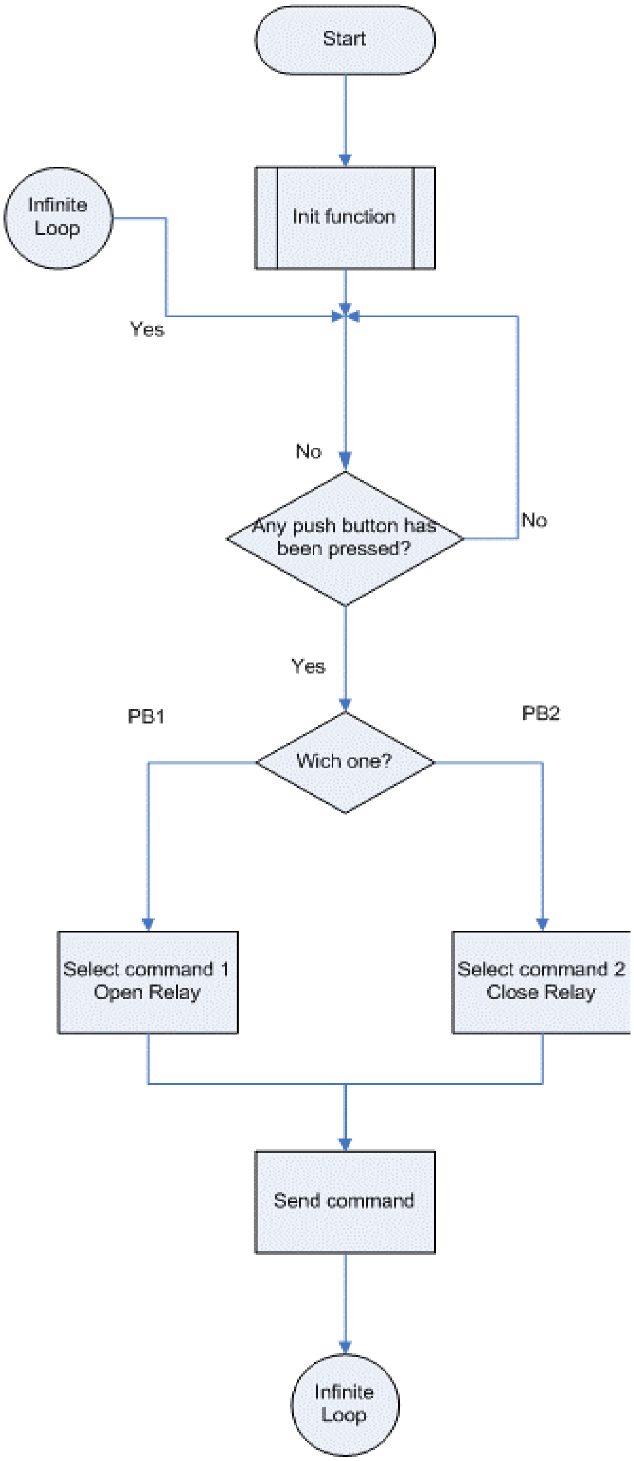

Start
Init function
Infinite Loop
Yes
No
Any push button has been pressed?
No
Yes
PB1
PB2
Wich one?
Select command 1 Open Relay
Select command 2 Close Relay
Send command
Infinite Loop

Figure 5-12. RKE/Remote Sensing Demo RG60 Baseboard Transmitter Flowchart

Regarding the RKE/Remote Sensing Demo receiver, the high level layer has four main tasks; as shown in Figure 5-13 and described here.

1. Waiting for commands. This module enters the MCU to an infinite loop until a valid command has been received from a valid transmitter.
2. Open relay. This module calls the respective functions for opening the relay, which is connected to a general-purpose I/O pin.
3. Close relay. This module calls the respective functions for closing the relay, which is connected to a general-purpose I/O pin.
4. Display and Update Data. This module executes functions for displaying updated data on LCD.

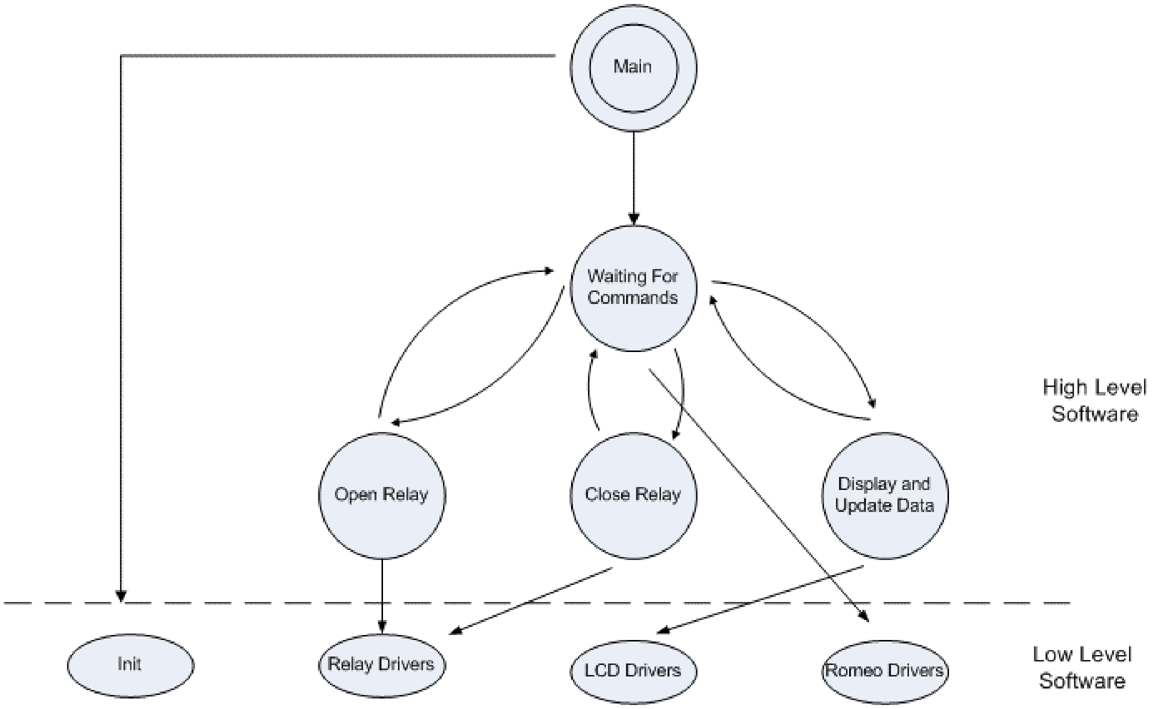


Figure 5-13. RKE / Remote Sensing Demo Receiver Program

Figure 5-14 shows the flowchart of the RKE/Remote Sensing Demo receiver program. After power on, the first action performed by MCU is configuring peripherals needed by subsequent functions. Among the settings performed by the MCU are:

- Enabling interrupts
- Disabling watchdog timer
- Configuring PLL
- Configuring timer for a timebase
- Configuring and enabling Romeo2 RF module
- Initialing software drivers for LEDs, relay, switch, and LCD

Following the configuring activity is an infinite loop, where MCU waits for a valid message received by Romeo2. If a valid massage is passed over the SPI to the MCU then Romeo2 software driver returns a ROMEO_MSG_READY status; therefore, a valid message is ready to be read.

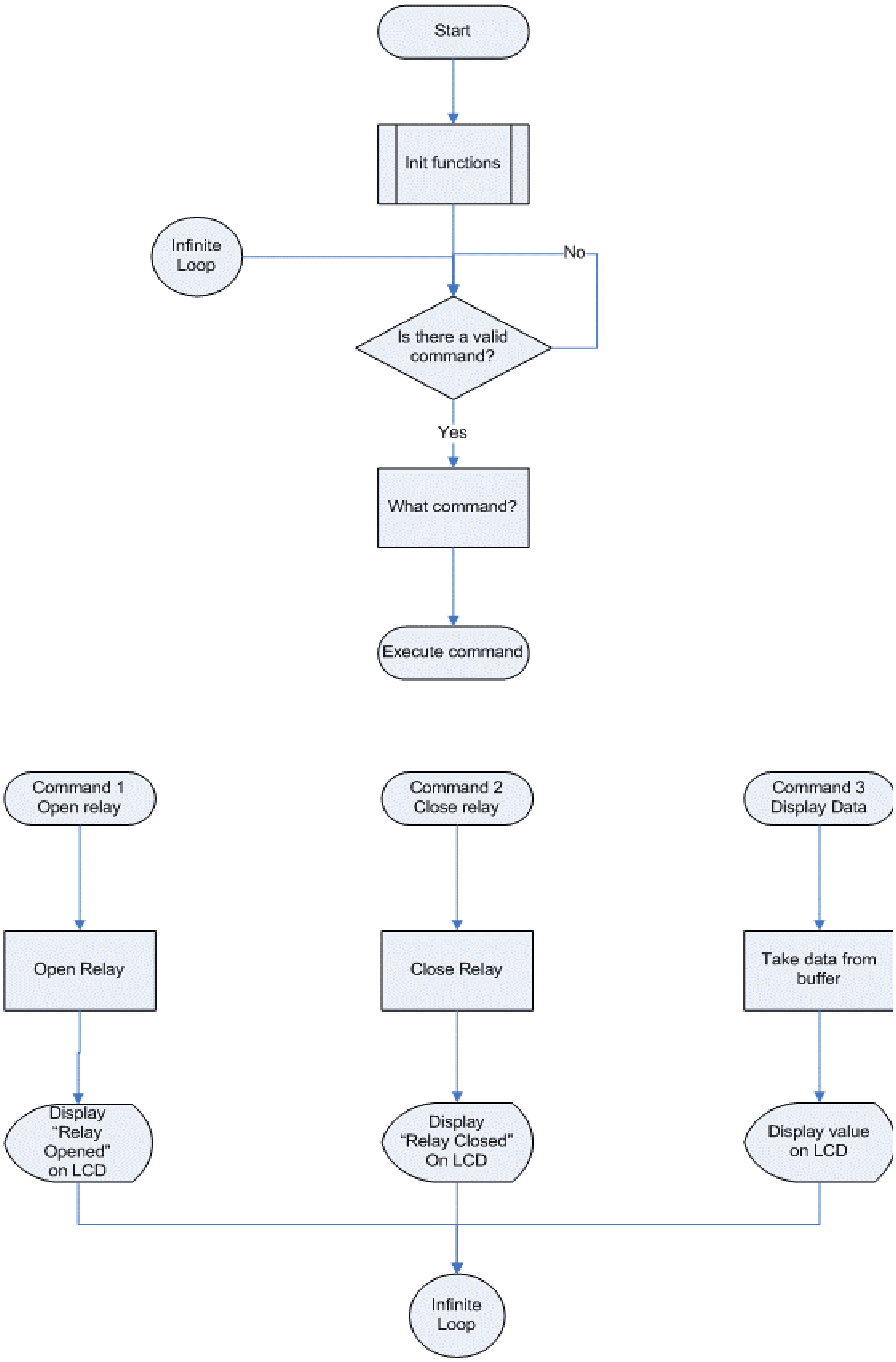


Figure 5-14. RKE / Remote Sensing Demo Receiver

This message contains the TEAMAC code sent by transmitter. This TEAMAC code is compared with a new one calculated by a receiver using command and rolling code counter. If these TEAMAC codes don't match, then the message is ignored and no action will be performed by the receiver. If the TEMAC codes match, the MCU will execute the command required. After MCU performs the required action, it updates the LCD data which are:

- Command
- Rolling code counter
- TEAMAC code
- Analog data

5.6.2 Home Connectivity Demo

This setup is similar to the RKE/remote sensing demo, except there are now multiple receivers. The QF4 transmitters can send messages to any number of receivers (2 shown in Figure 5-15) that can control some mains powered devices.

The system has at least two transmitters using the MC68HC908QF4. The QF4 transmitters can send simple 'open/close' commands that can control the relay and display some text on the LCD; it can also take an 'analog' input from a potentiometer and send it to a receiver when values need to be updated.

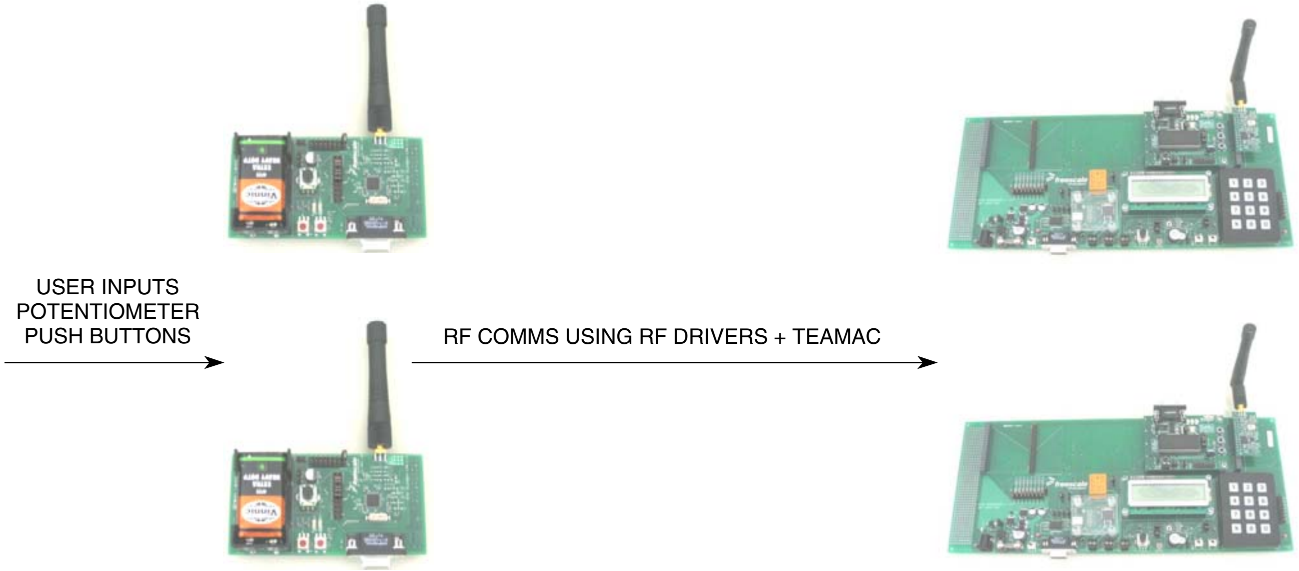


Figure 5-15. Simple System to Show Control of Lamps and other Mains Powered Items

The receivers have a baseboard with AP64 MCU and Romeo2 boards attached. Messages from transmitters to the receiver are sent using software drivers with the TEAMAC encryption code running on top. This software demo is compounded by two layers, the high and low levels.

Regarding Home Connectivity Demo transmitter, the high level layer has three tasks. These are shown in Figure 5-16 and described here.

1. Select receiver. This module selects the receiver; this means that transmitter can select which receiver will execute the sent command.
2. Read potentiometer. This module calls the analog-to-digital driver functions for reading the present value on the potentiometer.

3. Send command. This module calls Tango driver and TEMAC functions for sending certain command or data to a specified Rx, the ID of each receiver is inserted in data frame. There is an ID for each Tx defined by TEAMAC encryption key which is loaded in Tx and Rx memory. There are two possible commands, open and close relay; the sent command depends on which button has been pressed. Data is the value read from analog-to-digital converter.

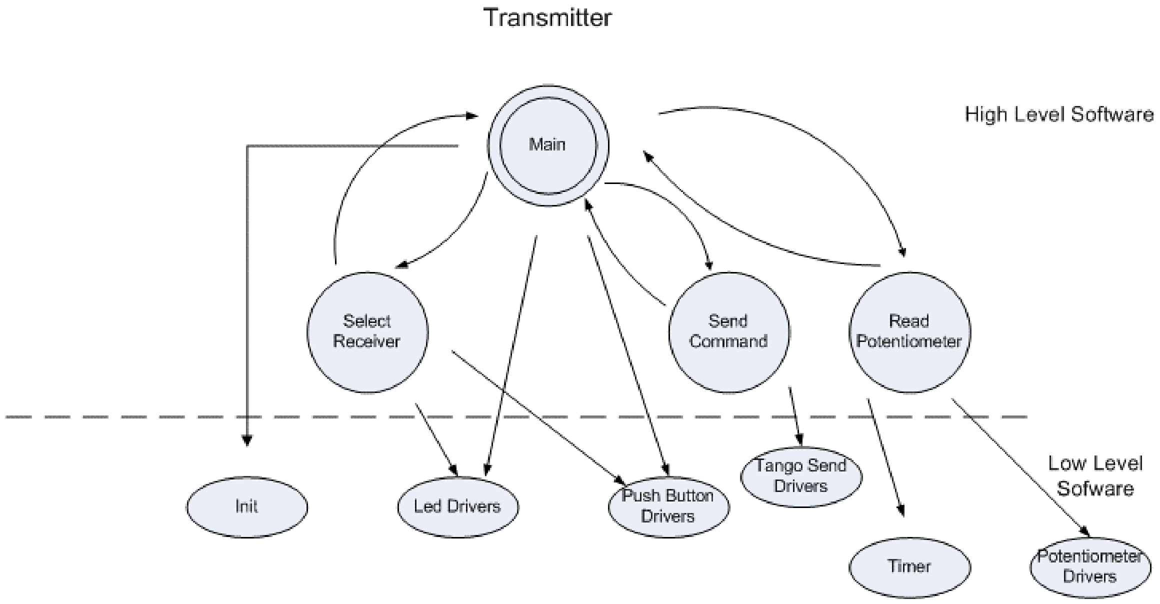


Figure 5-16. Home Connectivity Demo Transmitter

Figure 5-17 shows the flowchart of the QF4 transmitter program. After power on, the first action performed by MC68HC908QF4 is configuring peripherals needed by subsequent functions. Among the settings performed by the MCU are:

- Disabling watchdog timer
- Configuring keyboard interrupt module
- Configuring two general port I/O as outputs for driving two LEDs
- Initialing and enabling QF4 transmitting module
- Enabling interrupts

Following the configuring activity is an infinite loop, where MCU waits for 100 ms or an interrupt generated by the KBI module. If a period of 100 ms occurred, the ADC result register is read and stored in the DATA field of the QF4TxTransmitBuffer.

If a push button was pressed then a KBI interrupt is generated and the MCU executes the corresponding interrupt service routine (ISR). Inside this ISR, the pressed button is recognized and therefore a command is identified. This command is stored into the DATA field of the QF4TxTransmitBuffer. If both buttons are pressed at the same time, then the MCU enters on the select receiver state where the Rx ID field is changed. The MCU is placed in this state until a button is pressed or the select time has expired. If push button one is pressed while MCU is placed in this state, the Rx ID field is set with the receiver 1 ID number. If push button two is pressed then receiver 2 is selected. Pressing both or none of these buttons will select both receivers.

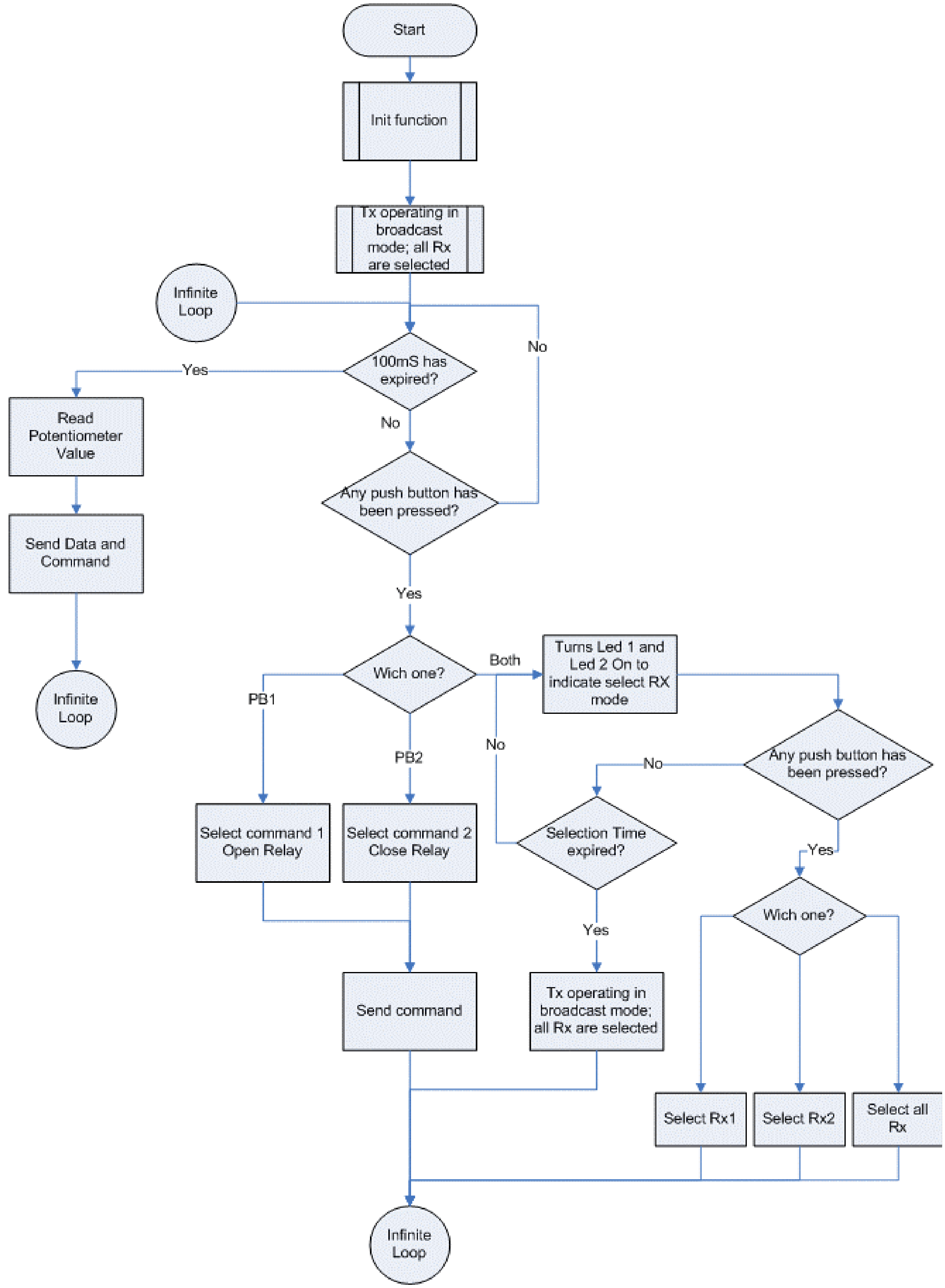

Start
Init function
Tx operating in broadcast mode; all Rx are selected
Infinite Loop
No
Yes
100mS has expired?
Read Potentiometer Value
No
Any push button has been pressed?
Send Data and Command
Yes
Infinite Loop
Both
Turns Led 1 and Led 2 On to indicate select RX mode
Wich one?
PB1
PB2
No
No
Any push button has been pressed?
Select command 1 Open Relay
Select command 2 Close Relay
Selection Time expired?
Yes
Yes
Wich one?
Send command
Tx operating in broadcast mode; all Rx are selected
Select Rx1
Select Rx2
Select all Rx
Infinite Loop

Figure 5-17. Home Connectivity Demo Transmitter Flowchart

Send command execution includes the TEAMAC algorithm, where the rolling code counter and the command number are encrypted prior to transmission. Hence, the transmit buffer contains the rolling code counter, the command number, data and four TEAMAC code bytes. After the MCU has sent the message, it is placed on an infinite loop waiting for either a KBI interrupt or a 100 ms delay for reading ADC.

Regarding Home Connectivity Demo receiver, the high level layer has five tasks. These are shown in Figure 5-18 and described here.

1. Waiting for commands. This module enters the MCU to an infinite loop until a valid command has been received from a valid Tx.
2. Turn lamp on. This module calls the respective functions for opening the relay connected to a general purpose I/O pin; it also calls TRIAC functions for smoothing ramp light level up.
3. Turn lamp off. This module calls the respective functions for closing the relay, which is connected to a general purpose I/O pin. It calls TRIAC functions for smoothing ramp light level down before closing relay.
4. Increase lamp intensity. This module executes the respective routines for increase the duty cycle of a PWM; it is generated with a timer module.
5. Decrease lamp intensity. This module executes the respective routines for decrease the duty cycle of a PWM; it is generated with a timer module.

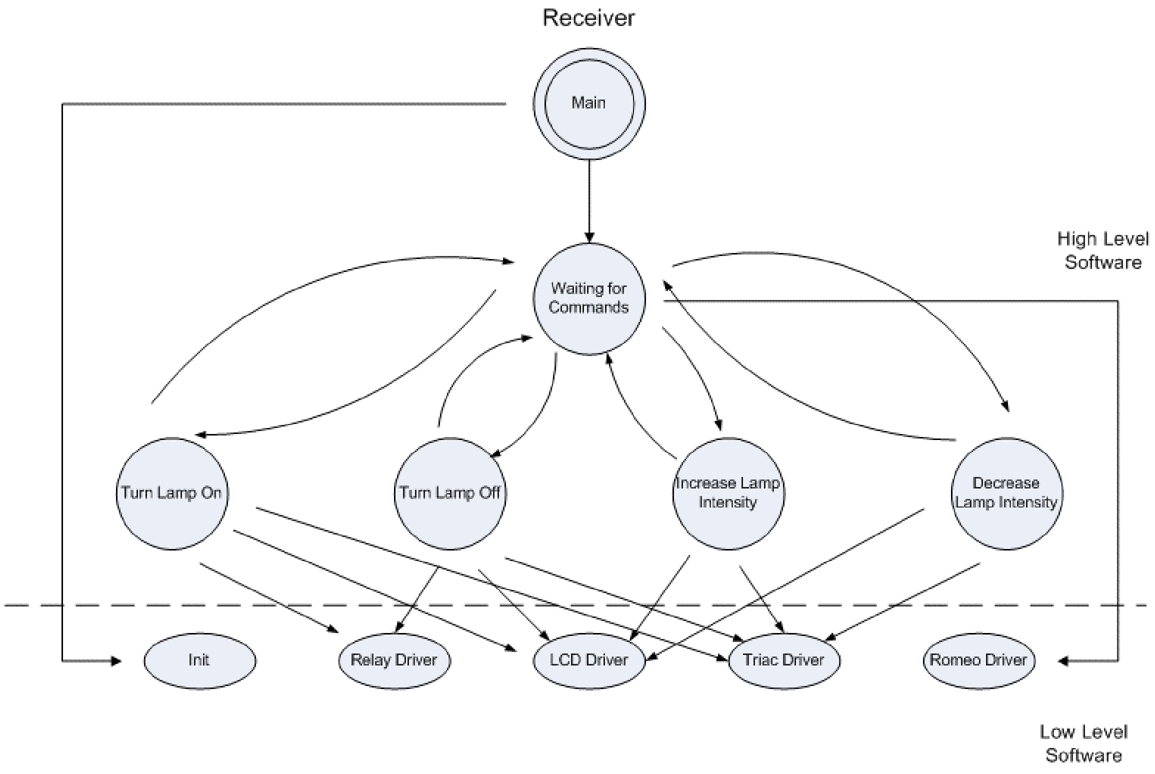


Figure 5-18. Home Connectivity Demo Receiver

Figure 5-19 shows the flowchart of the Home Connectivity Demo receiver program. After power on, the first action performed by MCU is configuring peripherals needed by subsequent functions. Among the settings performed by the MCU are:

- Enabling interrupts
- Disabling watchdog timer
- Configuring PLL
- Configuring timer for a timebase
- Configuring and enabling Romeo2 RF module
- Initialing software drivers for LEDs, Relay, Switch, and LCD

Following the configuring activity is an infinite loop, where MCU waits for a valid message received by Romeo2. If a valid massage is passed over the SPI to MCU then Romeo2 software driver returns a ROMEO_MSG_READY status. Therefore, a valid message is ready to be read.

This message contains the TEAMAC code sent by transmitter. This TEAMAC code is compared with a new one calculated by receiver using command and rolling code counter. If these TEAMAC codes don't match, then the message is ignored and no action will be performed by the receiver. In the case that the TEMAC codes match, the MCU will execute the command required. After the MCU performs the required action, it updates the LCD data which are command, rolling code counter, TEAMAC code, and analog data.

The analog data will be used for controlling duty cycle of the TRIAC, simulating a dimmer. When the relay is turned on the duty cycle is set to the lowest value and increases slowly until it reaches the analog value. This will smoothly turn on the load connected to the TRIAC circuit.

When the relay is turned off the duty cycle is set to the analog value and decreases slowly until it reaches the lowest possible value. This will smoothly turn off the load connected to the TRIAC circuit.

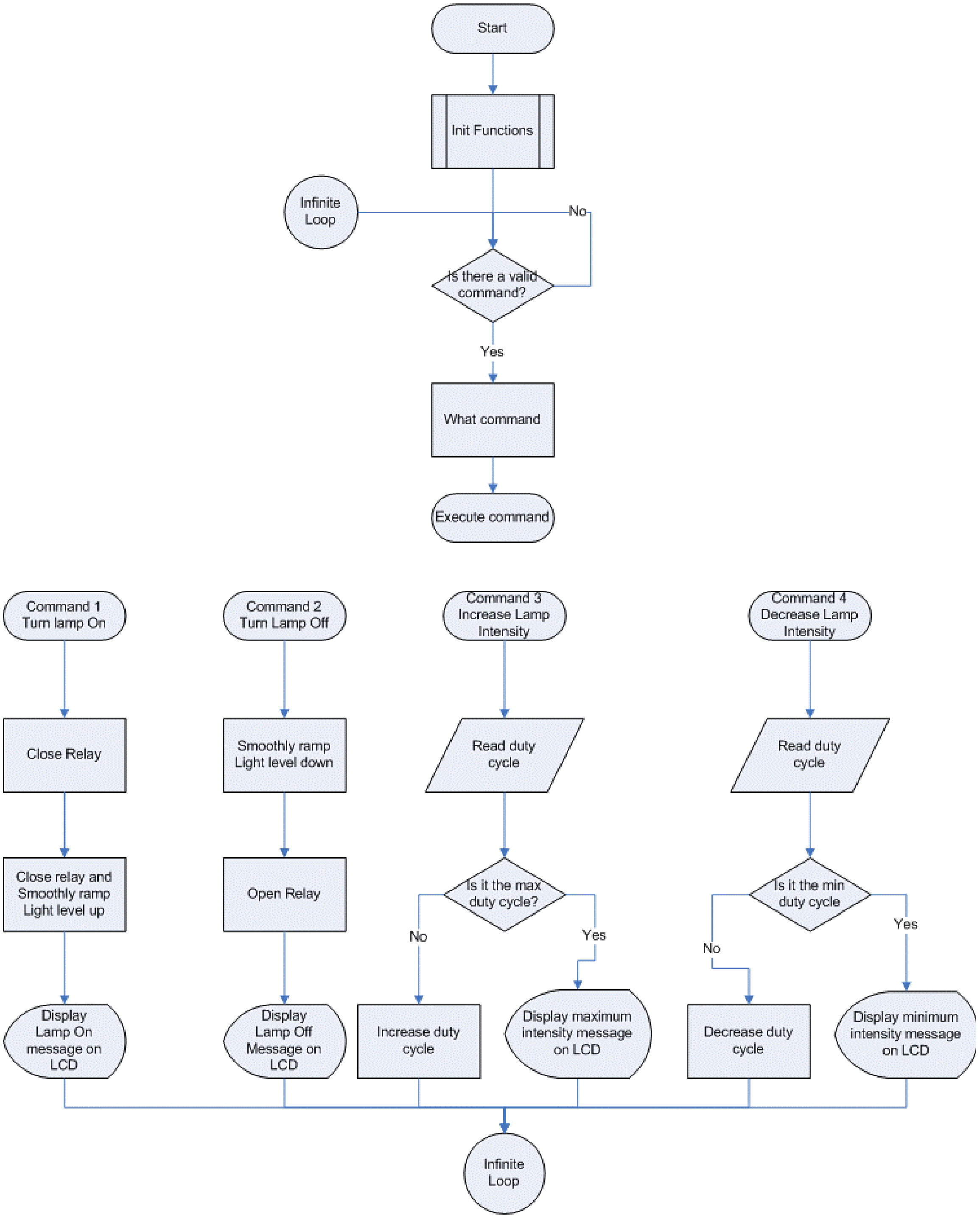

Start
Init Functions
Infinite Loop
No
Is there a valid command?
Yes
What command
Execute command
Command 1 Turn lamp On
Command 2 Turn Lamp Off
Command 3 Increase Lamp Intensity
Command 4 Decrease Lamp Intensity
Close Relay
Smoothly ramp Light level down
Read duty cycle
Read duty cycle
Close relay and Smoothly ramp Light level up
Open Relay
Is it the max duty cycle?
Is it the min duty cycle
No
Yes
No
Yes
Display Lamp On message on LCD
Display Lamp Off Message on LCD
Increase duty cycle
Display maximum intensity message on LCD
Decrease duty cycle
Display minimum intensity message on LCD
Infinite Loop

Figure 5-19. Home Connectivity Demo Receiver Flowchart

Chapter 6
Source Code

6.1 RKE Demo

6.1.1 RKEdemoAP64Rx1

6.1.1.1 Include Files

6.1.1.1.1 TEAMAC.h

Same as 6.2.1.1.1 TEAMAC.h

6.1.1.1.2 ROMEO.h

There is only one difference between the receivers. This is the `ROMEO_ID_VALUE` in 6.2.1.1.2 ROMEO.h. This define must have the value 0x55.

6.1.1.1.3 DRIVERSSWITCH.h

Same as 6.2.1.1.7 DRIVERSSWITCH.h

6.1.1.1.4 DRIVERSRELAY.h

Same as 6.2.1.1.6 DRIVERSRELAY.h

6.1.1.1.5 DRIVERSMASTER.h

Same as 6.2.1.1.8 DRIVERSMASTER.h

6.1.1.1.6 DRIVERSLEDS.h

Same as 6.2.1.1.5 DRIVERSLEDS.h

6.1.1.1.7 DRIVERSLCD.h

Same as 6.2.1.1.4 DRIVERSLCD.h

6.1.1.2 Source Code Files

6.1.1.2.1 TEAMAC.c

Same as 6.2.1.2.2 TEAMAC.c

6.1.1.2.2 START08.c

Same as 6.2.1.2.3 START08.c

6.1.1.2.3 ROMEO.c

Same as 6.2.1.2.4 ROMEO.c

6.1.1.2.4 MAIN.c

```
/******************************************************************************
*
*       Copyright (C) 2004 Freescale Semiconductor Mexico
*       All Rights Reserved
*
* Filename:     $RCSfile: main.c,v $
* Author:       $Author: a20701, a20702, r57191, a20705 $
* Locker:       $Locker: a20701, a20702, r57191, a20705 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:    Romeo2 with AP64, recieve msg with header
*
* History:
*
*
* Description: Probe in a the baseboard with AP64 and Romeo2
*              comunication with other component with Tango or Echo.
*
*
*
* Notes:
*
*
******************************************************************************/
#include <hidef.h>                   /* for EnableInterrupts macro */
#include <MC68HC908AP64.h>           /* Include peripheral declarations  */

#include "Romeo.h"                   /* Include Romeo driver header file */
#include "Teamac.h"                  /* Include Teamac driver header file */

#include "driversMaster.h"           /* Include general driver headers files */
#include "driversLeds.h"
#include "driversLcd.h"
#include "driversSwitch.h"
#include "driversRelay.h"

/* Timers */
extern UINT8 u8TimerLCD;

#define delay_ms(ms)        (gTimeBaseInterruptperms*ms)

/* Globar variables */
UINT8 flagBasePrintLCD;        /* Flag to controlate the LCD print */
UINT8 temp;                    /* Temporaly variable for conversions */
UINT8 impPot[3];               /* Array of decimal value of the dimmer */
UINT8 wichMAC[4];              /* Mac result of Teamac procces */
UINT8 wichCNT;                 /* Count number of the transmition */
UINT8 charPressed;             /* Last character sended from tango */

extern unsigned char romeoReceiveBuffer[];/* Declare Romeo receive buffer */

/*Declarations for TEAMAC*/
unsigned long MACreceived;
unsigned long cipherText[2];
unsigned long key[4];
unsigned long TEAMAC_Data[2];
unsigned long TEAMAC_Code;
#pragma CONST_SEG MY_SEG
const unsigned char TEAMAC_Key[8]={0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08};
#pragma CONST_SEG DEFAULT


/* Flash rate to indicate the frequency to program */
#define LED2_FLASH_RATE  0x7fff


/* Flag to indicate the status of Romeo */
extern tROMEO_STATUS romeoStatus;

/************************************************************************/

/* Declaration of functions */
/* Convert to decimal print from hexadecimal number */
/* Pre : Number in hexadecimal format and pointer to decimal array */
/* Post: Array of decimal values */
void Dec2Ascii(UINT8 Number, UINT8 *Destination);

/* Flash LED 1, duration */
/* Pre : LED2 pin configured as output */
/* Post: LED2 flashed once */
void FlashLED2(void)
{
    unsigned int i;
    LedOn(LED_ONE);
    for ( i=0;i < LED2_FLASH_RATE;i++) {}
    LedOff(LED_ONE);
    for ( i=0;i < LED2_FLASH_RATE;i++) {}
}


void main(void)
{

  /* Initialization of global variables */
  flagBasePrintLCD = 0;

  EnableInterrupts; /* enable interrupts */

  CONFIG1 = 17;                        /* Set the CONFIG1 register */
  /* PLL Initialization */

  /* CONFIG2: STOPICLKEN=1,STOPRCLKEN=0,STOPXCLKEN=0,OSCCLK1=0,
              OSCCLK0=0,??=0,??=0,SCIBDSRC=0 */
  CONFIG2 = 128;                       /* Set the CONFIG2 register */
  PCTL_BCS = 0;                        /* Select clock source from XTAL */
  PCTL_PLLON = 0;                      /* Disable the PLL */
  PMS = 900;                           /* Set the multiplier */
  PMRS = 192;                          /* Set the range select */
  PCTL = 0;
  PCTL_VPR = 2;
  PBWC = 128;                          /* Select the operating modes */
  PCTL_PLLON = 1;                      /* Enable the PLL */
  while(!PBWC_LOCK);                   /* Wait */
  PCTL_BCS = 1;                        /* Select clock source from PLL */
  __asm("nop");
  __asm("nop");
  /* Timer initialization */
  T1SC_TOIE = 1;                         /* Enable overflow interrupt */
  T1SC_PS0 = 0;                          /* Select prescale divisor */
  T1SC_PS1 = 1;
//  T1SC_PS1 = 0;                        /* For xtal = 9.8304 MHz */
  T1SC_PS2 = 0;                          /* For Fbus = 7.3728 MHz;
                                          remember Fbus = xtal/4 */
//  T1MOD = 0x0171;                      /* For stops of 200 us, this delay is
//                                          the value of a variable in driversMaster.h */
  T1MOD = 0x0093;                        /* For stops of 20 us, this delay is
                                            the value of a variable in driversMaster.h */

  T1SC_TSTOP = 0;                        /* Normal operation */

  /* Initialization of drivers */
  LedsInit();
  SwitchInit();
  RelayInit();
  LCDInit();


  FlashLED2();         // Two flashes tu indicate the frequency of 315 Mhz

  RomeoInitialise();   // Initialise Romeo driver with settings in Romeo.h file
  RomeoChangeConfig((ROMEO_CR1_VALUE & 0xBf),ROMEO_ID_VALUE ,ROMEO_CR3_VALUE);
  RomeoEnable();       // This enables Romeo to receive messages

  for(;;) {


    if (u8TimerLCD == 0) LCDTimeBase();

    switch (RomeoStatus()) {

      case ROMEO_MSG_READY:

        TEAMAC_Data[0]=(unsigned long)romeoReceiveBuffer[1];
        TEAMAC_Data[1]=(unsigned long)romeoReceiveBuffer[2];
        char2Long(&MACreceived,&romeoReceiveBuffer[4]);

        char2Long(key, TEAMAC_Key);
        char2Long(key+1, TEAMAC_Key+1);
        char2Long(key+2, TEAMAC_Key+2);
        char2Long(key+3, TEAMAC_Key+4);

        encipher(TEAMAC_Data, cipherText, key);

        TEAMAC_Code = cipherText[0] ^ cipherText[1];

         if(MACreceived == TEAMAC_Code) {

          wichMAC[0] = romeoReceiveBuffer[4];
          wichMAC[1] = romeoReceiveBuffer[5];
          wichMAC[2] = romeoReceiveBuffer[6];
          wichMAC[3] = romeoReceiveBuffer[7];
          wichCNT = romeoReceiveBuffer[1];

          if(romeoReceiveBuffer[2]==0x02) {          // Value of triac

            Dec2Ascii(romeoReceiveBuffer[3],impPot);

          }
          else if (romeoReceiveBuffer[2]==0x01) {   // Open relay
//            if (RelayStatus() != relayOn) {
               RelayOn();
//             }

           }
           else if (romeoReceiveBuffer[2]==0x00)  {   // Close relay

//            if (RelayStatus() != relayOff) {
              RelayOff();
//            }

           }
           else if (romeoReceiveBuffer[2]==0x03)  {   // Character sended

            charPressed = romeoReceiveBuffer[3];

           }
        }

        romeoReceiveBuffer[0] = romeoReceiveBuffer[0] & 0x7f;
                                                      // Clear buffer full flag
        break;

      case ROMEO_OVERRUN:

        romeoReceiveBuffer[0] = romeoReceiveBuffer[0] & 0x7f;
        break;

      case ROMEO_CHECKSUM_ERROR:

        romeoReceiveBuffer[0] = romeoReceiveBuffer[0] & 0x7f;
                                                      // Clear buffer full flag
        break;

      case ROMEO_DISABLED:

        break;

      case ROMEO_NO_MSG:

        break;

      default:

        break;

    }


    if (LCDStatus() == LCD_STATUS_READY) {
      if (flagBasePrintLCD == 0) {  // MAC
        flagBasePrintLCD = 1;
        LCDCursor(0x08);
      }
      else if (flagBasePrintLCD == 1) {
        flagBasePrintLCD = 2;
        LCDPrint("MAC:",4);
      }
      else if (flagBasePrintLCD == 2) {  // ANALOG
        flagBasePrintLCD = 3;
        LCDCursor(0x40);
      }
      else if (flagBasePrintLCD == 3) {
        flagBasePrintLCD = 4;
        LCDPrint("ANALOG: ",8);
      }
      else if (flagBasePrintLCD == 4) {  // CNT
        flagBasePrintLCD = 5;
        LCDCursor(0x4A);
      }
      else if (flagBasePrintLCD == 5) {
        flagBasePrintLCD = 6;
        LCDPrint("CNT:",4);
      }
      else if (flagBasePrintLCD == 6) {  // Relay
        flagBasePrintLCD = 7;
        LCDCursor(0x00);
      }
      else if (flagBasePrintLCD == 7) {
        flagBasePrintLCD = 8;
        if (RelayStatus()==RELAY_ON) {
          LCDPrint("OPEN ",5);
        }
        else {
          LCDPrint("CLOSE",5);
        }
      }
      else if (flagBasePrintLCD == 8) {  // Triac
        flagBasePrintLCD = 9;
        LCDCursor(0x47);
      }
      else if (flagBasePrintLCD == 9) {
        flagBasePrintLCD = 10;
        LCDPrint(impPot,3);
      }
      else if (flagBasePrintLCD == 10) {  // MAC
        flagBasePrintLCD = 11;
        LCDCursor(0x0C);
      }
      else if (flagBasePrintLCD == 11) {
        flagBasePrintLCD = 12;
        LCDPrint(wichMAC,4);
      }
      else if (flagBasePrintLCD == 12) {  // Count
        flagBasePrintLCD = 13;
        LCDCursor(0x4E);
      }
      else if (flagBasePrintLCD == 13) {
        flagBasePrintLCD = 14;
        temp = (((wichCNT)>>4) & 0x0F) + '0';
        if (temp > '9') temp += 7;
        LCDPrint(&temp,1);
      }
      else if (flagBasePrintLCD == 14) {
        flagBasePrintLCD = 15;
        temp = ((wichCNT) & 0x0F) + '0';
        if (temp > '9') temp += 7;
        LCDPrint(&temp,1);
      }
      else if (flagBasePrintLCD == 15) {   // Character pressed
        flagBasePrintLCD = 16;
        LCDCursor(0x06);
      }
      else if (flagBasePrintLCD == 16) {
        flagBasePrintLCD = 0;
        LCDPrint(&charPressed,1);
      }
    }

  }
}

void interrupt 7 timeOverFlowInterrupt(void) {

    T1SC &= 0x7F;  // Reset the flag
    if (u8TimerLCD>0) u8TimerLCD--;

}

void Dec2Ascii(UINT8 Number, UINT8 *Destination) {

    UINT8 ThirdDigit = 0, SecondDigit = 0, FirstDigit = 0;

    ThirdDigit = (UINT8)(Number/100);
    Number = Number-(ThirdDigit*100);
    SecondDigit= (UINT8)(Number/10);
    Number = Number-(SecondDigit*10);
    FirstDigit = Number;

    *Destination = ThirdDigit  | 0x30;
    Destination++;
    *Destination = SecondDigit | 0x30;
    Destination++;
    *Destination = FirstDigit  | 0x30;
}
```

6.1.1.2.5 DRIVERSSWITCH.c

Same as 6.2.1.2.9 DRIVERSSWITCH.c

6.1.1.2.6 DRIVERSRELAY.c

Same as 6.2.1.2.8 DRIVERSRELAY.c

6.1.1.2.7 DRIVERSLEDS.c

Same as 6.2.1.2.7 DRIVERSLEDS.c

6.1.1.2.8 DRIVERSLCD.c

Same as 6.2.1.2.6 DRIVERSLCD.c

6.1.2 RKEdemoQF4Tx1

6.1.2.1 Include Files

6.1.2.1.1 TEAMAC.h

Same as 6.2.1.1.1 TEAMAC.h

6.1.2.1.2 ADC.h

Same as 6.2.2.1.2 ADC.h

6.1.2.1.3 KBI.h

Same as 6.2.2.1.3 KBI.h

6.1.2.1.4 TANGOQF4.h

Same as 6.2.2.1.4 TANGOQF4.h

6.1.2.2 Source Code Files

6.1.2.2.1 MAIN.c

```
#include <hidef.h> /* for EnableInterrupts macro */
#include <MC68HC908QY4.h> /* include peripheral declarations */
#include "tangoQF4.h"
#include "teamac.h"
#include "ADC.h"
#include "KBI.h"

#define delta 0x9E3779B9

extern unsigned char tangoTransmitBuffer[TANGO_MAX_DATA_SIZE+2];

unsigned char resultADC=0;
unsigned char InputData=0;

unsigned long key[4];
unsigned long TEAMAC_Data[2];
unsigned long TEAMAC_Code;
unsigned char n;

#pragma CONST_SEG TEAMAC_KEY
const unsigned char TEAMAC_Key[8]={0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08};
#pragma CONST_SEG DEFAULT



void main(void) {


      unsigned int i;
      unsigned char count = 0;    /* Data byte sent in rf message */



    /* Disable watchdog, enable reset pin, enable debug pin   */


      CONFIG2 = 0x00;
      CONFIG1 = 0x01;

      /*Outputs*/
      DDRB_DDRB3 = 1;
      DDRA_DDRA4=  1;
      PTB_PTB3 = 0;
      PTA_PTA4 = 0;

    ADCinit();
    KBIinit();
```

```
  EnableInterrupts;
  TangoInitialise();/*Configures Tango driver using settings from Tango.H*/
  TangoEnable();    /*This enables the Tango ic and starts 2ms delay     */
                    /*(Tango ic needs 2ms to stabalise                   */
while(TangoDriverStatus() == TANGO_IN_ENABLE_DELAY){}
                                         /*  Wait until end of 2ms delay */

   tangoTransmitBuffer[0] = 0x55;        /* Put message ID in tx buffer  */
   tangoTransmitBuffer[1] = 7;           /* Put data length in tx buffer */
   tangoTransmitBuffer[2] = 0x00;        /* Set data to 0                */
   tangoTransmitBuffer[3] = 0x00;        /* Set data to 0                */
   tangoTransmitBuffer[4] = 0x00;        /* Set data to 0                */
   tangoTransmitBuffer[5] = 0x00;
   tangoTransmitBuffer[6] = 0x00;
   tangoTransmitBuffer[7] = 0x00;
   tangoTransmitBuffer[8] = 0x00;
   tangoTransmitBuffer[9] = 0x00;

  for (i = 0; i <= 10; i++){
      TangoSendPreamble_ID();
      while(TangoDriverStatus() != TANGO_READY ){}
                                         /* Wait until message gone      */
     }

TangoSendData();                            /* Send data                 */
while(TangoDriverStatus() != TANGO_READY ){}/* Wait until message gone   */
TangoDisable();

      /* Main loop - goes around this loop for each keypress */
  for (;;){


   /* Wait until a button pressed or a new ADC value is present*/
       while ( InputData==0 ){


      while (! ADSCR_COCO )
          ;
      for (i = 0; i< 0x7ff; i++){
        if(InputData !=0)
          break;
        }

      if(resultADC != ADR)
        if(resultADC < (ADR-1) || resultADC > (ADR+1)){
          resultADC=ADR;
          InputData=3;
          }

      }


         switch (InputData){

           case  1:{

                 PTB_PTB3 = 1;
                tangoTransmitBuffer[2] = ++count;
                                          /* Put data byte in tx buffer  */
                  tangoTransmitBuffer[3] = 0x00;
                  tangoTransmitBuffer[4] = 0x00;
                 break;
                 }
           case  2:{

                PTB_PTB3 = 1;
                tangoTransmitBuffer[2] = ++count;
                                          /* Put data byte in tx buffer  */
                  tangoTransmitBuffer[3] = 0x01;
                  tangoTransmitBuffer[4] = 0x00;
                  break;
               }

            case  3:{

                 PTA_PTA4 = 1;
                tangoTransmitBuffer[2] = ++count;
                                          /* Put data byte in tx buffer  */
                tangoTransmitBuffer[3] = 0x02;
                tangoTransmitBuffer[4] = resultADC;
                break;
                }

            default:{break;}

            }

        InputData=0;

  /********* START OF TEAMAC CODE  *****///
  TEAMAC_Data[0]=(unsigned long)tangoTransmitBuffer[2];
  TEAMAC_Data[1]=(unsigned long)tangoTransmitBuffer[3];

  char2Long(key,   &TEAMAC_Key[0]);
  char2Long(key+1, &TEAMAC_Key[1]);
  char2Long(key+2, &TEAMAC_Key[2]);
  char2Long(key+3, &TEAMAC_Key[4]);

  TEAMAC_Code = 0;
  n = 32;

  while(n-- > 0)
    {
    TEAMAC_Data[0] += (((TEAMAC_Data[1] << 4) ^ (TEAMAC_Data[1] >> 5)) + \
                      TEAMAC_Data[1]) ^ (TEAMAC_Code + key[TEAMAC_Code&3]);
    TEAMAC_Code += delta;
    TEAMAC_Data[1] += (((TEAMAC_Data[0] << 4) ^ (TEAMAC_Data[0] >> 5)) + \
              TEAMAC_Data[0]) ^ (TEAMAC_Code + key[(TEAMAC_Code>>11) & 3]);
    }

  TEAMAC_Code = TEAMAC_Data[0] ^ TEAMAC_Data[1];;
  Long2char(&tangoTransmitBuffer[5],&TEAMAC_Code);
  /****** END OF TEAMAC CODE ******/


   TangoEnable();    /* This enables the Tango ic and starts 2ms delay */
                     /* (Tango ic needs 2ms to stabalise) */

    while(TangoDriverStatus() == TANGO_IN_ENABLE_DELAY){}
                                             /*Wait until end of 2ms delay*/
    /* Send Preamble_ID 10 times */
      for ( i = 0; i <= 10; i++){
         TangoSendPreamble_ID();
         while(TangoDriverStatus() != TANGO_READY ){}
```

```
                                                   /* Wait until message gone */
           }

         TangoSendData(); /* Send Data */
         while(TangoDriverStatus() != TANGO_READY ){}
                                                   /* Wait until message gone */
         TangoDisable();

       PTB_PTB3 = 0;
       PTA_PTA4 = 0;

      }/*LOOP FOREVER*/

}/*END OF MAIN*/
```

6.1.2.2.2 ADC.c

Same as 6.2.2.2.2 ADC.c

6.1.2.2.3 KBI.c

Same as 6.2.2.2.3 KBI.c

6.1.2.2.4 TEAMAC.c

Same as 6.2.2.2.4 TEAMAC.c

6.1.2.2.5 TANGOQF4.c

Same as 6.2.2.2.5 TANGOQF4.c

6.1.2.2.6 START08.c

Same as 6.2.2.2.6 START08.c

6.1.3 RKEdemoRG60Tx2

6.1.3.1 Include Files

6.1.3.1.1 TEAMAC.h

```
#ifndef teamac_h
#define teamac_h

void TEAMAC(void);
void char2Long(unsigned long *pDest,const unsigned char *pSrce);
void Long2char(unsigned char *pDest,unsigned long *pSrce);
void encipher(unsigned long *v, unsigned long *w,unsigned long *k);

#endif
```

6.1.3.1.2 TANGO.h

```
#ifndef TANGO_H
#define TANGO_H
/******************************************************************************
*
*       Copyright (C) 2004 Motorola, Inc.
*       All Rights Reserved
*
* Filename:     $RCSfile: Tango.h,v $
* Author:       $Author: r29541 $
* Locker:       $Locker: r29541 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:    Tango3 software driver header file for HCS08
*
* History:
*
*
* Description:   This is header file for Tango3 software driver for HCS08
*
*
*
* Notes:
*
******************************************************************************/

/*****************************************************************************/
/* This section defines some symbols for use below. DO NOT EDIT!             */
#define TANGO_FSK    1
#define TANGO_OOK   0

#define TANGO_HIGH_BAND   1
#define TANGO_LOW_BAND   0
/*****************************************************************************/


/*****************************************************************************/
/*            THIS SECTION CONTAINS VALUES YOU MUST DEFINE!                  */
/*                                                                           */
#include "MC9S08RG60.h"                 /* Include peripheral declarations   */

#define TANGO_TIMER_ADDRESS     0x30    /* Location of 1st timer register    */
#define TANGO_TIMER_CHANNEL     1       /* Define which timer channel to use */
                                        /* Note:timer channels start from 0  */

#define TANGO_MAX_DATA_SIZE 12          /* Max size of data                  */

                                        /* Set TANGO Mode                    */
#define  TANGO_MODE_VALUE TANGO_OOK     /* TANGO_OOK or TANGO_FSK            */

                                        /* Set timer clock speed in Hz       */
#define TANGO_TIMER_CLOCK_SPEED  8000000

#define TANGO_TIMER_CLOCK_SOURCE    1    /* Use to set clock source for timer */
                                        /* 1 = Bus clock                     */
                                     /* 2 = XCLK- note,not all mcus have XCLK*/
                                        /* 3 = Ext clock                     */

#define TANGO_TIMER_PRESCALE    1       /* Specify timer prescaler value     */
                                         /* NOTE: If using DATACLK from       */
                                         /* Tango ic, prescaler will be forced*/
                                         /* to 1                              */

#define TANGO_TIMER_DISABLE   1 /* Allows driver to turn off timer after use  */
                               /* Delete this #define if you want timer to   */
                               /* stay on                                    */


#define TANGO_CRYSTAL_FREQUENCY  9843700    /* Crystal frequency (in Hz) */
                                            /* Typical values used       */
                                            /* RF Output                 */
                                            /* 315MHz  - 9843700         */
                                            /* 434MHz  - 13560000        */
                                            /* 868MHz  - 13560000        */



                                          /* Set Tango Band                  */
                                          /* TANGO_HIGH_BAND or TANGO_LOW_BAND*/
#define TANGO_BAND_VALUE   TANGO_HIGH_BAND/* High band - 315, 434 MHz        */
                                          /* Low band - 868MHz, 928MHz       */

                                          /* Set Tango data rate in Hz (before*/
#define TANGO_DATA_RATE      2400         /* Manchester encoding)            */


#define TANGO_ENABLE        PTCD_PTCD1    /* Define pin used for enable     */
                                          /* Defined for Sergio's Board */
#define TANGO_ENABLE_DDR    PTCDD_PTCDD1  /* If hardwired,delete #defines   */
                                          /* Defined for Sergio's Board */


/*****************************************************************************/
/* These may be omitted depending on the hardware setup                      */


#define TANGO_MODE          PTED_PTED0    /* Define pin used for mode select */
#define TANGO_MODE_DDR      PTEDD_PTEDD0  /* If hardwired,delete #defines    */

#define TANGO_BAND          PTAD_PTAD2    /* Define pin for band select      */
#define TANGO_BAND_DDR      PTADD_PTADD2  /* If hardwired,delete #defines    */

#define TANGO_ENABLE_PA     PTED_PTED1 /*Define pin used for Power amp enable*/
#define TANGO_ENABLE_PA_DDR  PTEDD_PTEDD1 /* If hardwired, delete #defines   */
/*****************************************************************************/

/*****************************************************************************/
/* This defines default values for  #defines in the Tango.h , or prints      */
/* errors if missing or incorrect values have been chosen                    */
/*                        DO NOT EDIT THIS SECTION!!                         */

#ifndef TANGO_TIMER_ADDRESS
#error "You must #define symbol TANGO_TIMER_ADDRESS in Tango.H header file"
#endif

#ifndef TANGO_TIMER_CHANNEL
#error "You must #define symbol TANGO_TIMER_CHANNEL in Tango.H header file"
#endif

#ifndef TANGO_MAX_DATA_SIZE
#error "You must #define symbol TANGO_MAX_DATA_SIZE in Tango.H header file"
#endif
```

```
#if TANGO_MAX_DATA_SIZE > 127
#error "TANGO_MAX_DATA_SIZE in file Tango.h must be in range 0- 127"
#endif


#ifndef TANGO_MODE_VALUE
#error "You must #define symbol TANGO_MODE_VALUE in Tango.H header file"
#endif

#if TANGO_MODE_VALUE ==TANGO_OOK
        //If OK, do nuthin
#else
    #if TANGO_MODE_VALUE ==TANGO_FSK
        //If OK, do nuthin
    #else
        #error "You must set TANGO_MODE_VALUE to TANGO_OOK or TANGO_FSK in \
                    Tango.H header file"
    #endif
#endif


#ifndef TANGO_TIMER_CLOCK_SPEED
#error  "You must #define symbol TANGO_TIMER_CLOCK_SPEED in Tango.h header file"

#endif

#ifndef TANGO_TIMER_CLOCK_SOURCE
#error  "You must #define symbol TANGO_TIMER_CLOCK_SOURCE in Tango.h header \
             file"
#endif


#ifndef TANGO_TIMER_PRESCALE
#error "You must #define symbol TANGO_TIMER_PRESCALE in Tango.h header file"
#endif


#ifndef TANGO_CRYSTAL_FREQUENCY
#error "You must #define symbol TANGO_CRYSTAL_FREQUENCY in Tango.h header file"
#endif



#if TANGO_BAND_VALUE ==TANGO_HIGH_BAND
                                            /* If OK, do nothing */
#else
    #if TANGO_BAND_VALUE ==TANGO_LOW_BAND
                                            /* If OK, do nothing */
    #else
        #error "You must set TANGO_BAND_VALUE to TANGO_HIGH or TANGO_LOW in \
                Tango.H header file"
    #endif
#endif


#ifndef TANGO_DATA_RATE
#error "You must #define symbol TANGO_DATA_RATE in Tango.h header file"
#endif
```

```
/***************************************************************************/
/*  This section defines various values used in the driver                 */
/*                         DO NOT EDIT THIS SECTION!!                      */


#if TANGO_TIMER_CLOCK_SOURCE == 3
    #define TANGO_TIMER_CLK_IN_CHANNEL  0 /* Timer channel used for clk in */
                                          /* (usually timer ch 0 on HCS08  */
                                          /* Delete if not using clk input */
#endif



#ifdef TANGO_TIMER_CLK_IN_CHANNEL       /* If using an external clock source */
    #define TANGO_TIMER_MODULUS  ((TANGO_CRYSTAL_FREQUENCY/64)/TANGO_DATA_RATE)

    #define TANGO_2MS_EXT_H (((TANGO_CRYSTAL_FREQUENCY/500)/256)/64)
                           /* If using ext clock,need these to set 2ms delay */
    #define TANGO_2MS_EXT_L ((TANGO_CRYSTAL_FREQUENCY/500)/64)


#else                                      /* If using internal clock source */
    #define TANGO_TIMER_MODULUS  ((TANGO_TIMER_CLOCK_SPEED/TANGO_DATA_RATE)\
                                /TANGO_TIMER_PRESCALE)

    #if ( (TANGO_TIMER_CLOCK_SPEED/500)/TANGO_TIMER_MODULUS ) == 0
    #define TANGO_2MS_DELAY 1
    #else
    #define TANGO_2MS_DELAY  ((TANGO_TIMER_CLOCK_SPEED/500)/TANGO_TIMER_MODULUS)
    #endif

#endif

#define TANGO_HALF_TIMER_MODULUS   (TANGO_TIMER_MODULUS/2)

#define TANGO_MODH  (TANGO_TIMER_MODULUS/256)
#define TANGO_MODL  (TANGO_TIMER_MODULUS)

#define TANGO_COMH  (TANGO_HALF_TIMER_MODULUS/256)
#define TANGO_COML  (TANGO_HALF_TIMER_MODULUS)




typedef union
{
  unsigned char Byte;
  struct
  {
    unsigned char enabled  :1;    /* 1 = Tango enabled, 0 = Tango disabled    */
    unsigned char enableDelay :1; /* 1 = in 2 ms delay after enabling         */
    unsigned char busy    :1;     /* 1 = currently sending a message, 0= idle */
    unsigned char res1    :1;     /* not used                                 */
    unsigned char eomFlag  :1;    /* 1 = eom required, 0 = no eom required    */
    unsigned char res2    :3;     /* not used                                 */
  }Bits;
}tTANGO_STATUS;


/*    Driver states          */
#define TANGO_DISABLED      0
#define TANGO_READY        1
#define TANGO_IN_ENABLE_DELAY    2
```

```
#define TANGO_BUSY        3

/* Internal state machine states */
#define TANGO_ENABLE_DELAY  0
#define TANGO_START      1
#define TANGO_PREAMBLE_1  2
#define TANGO_PREAMBLE_2  3
#define TANGO_SEND_BYTE    4
#define TANGO_EOM_1      5
#define TANGO_EOM_2      6
#define TANGO_END      7
#define TANGO_EXTRA_BIT    8

/*   Constants      */
#define TANGO_OOK_HEADER   0x60    /* Header value = 0110 (4 MSbits)         */
#define TANGO_FSK_HEADER  0x06     /* FSK preamble (4 0's) and Header (0110) */


/* Timer control reg masks */
#define TANGO_TIMER_ON   (TANGO_TIMER_CLOCK_SOURCE*8)
                                      /* OR this value to timer control */
                                      /* reg to enable clock            */
                                      /* NOTE, cannot be used to switch */
                                      /* from clock to clock            */

#define TANGO_TIMER_OFF    0xE7
                   /* AND this value to timer ctrl reg to disable clock */


/* Timer register offsets  */
/* Register address offsets for normal S08 timer */
                                                      /* Tmr status/ctrl reg */
#define TANGO_TPMxSC    *(unsigned char *)(TANGO_TIMER_ADDRESS+0)
                                                          /* Timer counter H */
#define TANGO_TPMxCNTH  *(unsigned char *)(TANGO_TIMER_ADDRESS+1)
                                                          /* Timer counter L */
#define TANGO_TPMxCNTL  *(unsigned char *)(TANGO_TIMER_ADDRESS+2)
                                                          /* Timer modulus H */
#define TANGO_TPMxMODH  *(unsigned char *)(TANGO_TIMER_ADDRESS+3)
                                                          /* Timer modulus L */
#define TANGO_TPMxMODL  *(unsigned char *)(TANGO_TIMER_ADDRESS+4)

/* Registers for each timer channel */
#define TANGO_TPMxCxSC  *(unsigned char *)(TANGO_TIMER_ADDRESS+5+\
                 (3*TANGO_TIMER_CHANNEL)+0)
#define TANGO_TPMxCxVH  *(unsigned char *)(TANGO_TIMER_ADDRESS+5+\
                 (3*TANGO_TIMER_CHANNEL)+1)
#define TANGO_TPMxCxVL  *(unsigned char *)(TANGO_TIMER_ADDRESS+5+\
                 (3*TANGO_TIMER_CHANNEL)+2)

/* Function prototypes */
void TangoSendData(void);
void TangoSendPreamble_ID(void);
void TangoSendMessageNoHeader( unsigned char idRepeat);
interrupt void TangoTimerInterrupt(void);
void TangoInitialise(void);
void TangoEnable(void);
void TangoDisable(void);
unsigned char TangoDriverStatus(void);
void TangoCalculateChecksum(void);

#endif //TANGO_H
```

6.1.3.1.3 DRIVERSSWITCH.h

```
#include "driversMaster.h" /* Include peripheral declarations */


/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/*
 * Comment the lines for disables the switch functionality
 */
#define SWITCH_ONE      PTAD_PTAD2              /* Data switch 0 */
#define SWITCH_TWO      PTED_PTED6            /* Data switch 1 */
#ifdef SWITCH_ONE
   #define SWITCH_ONE_PE  PTAPE_PTAPE2        /* Pullup Enable switch 0 */
   #define SWITCH_ONE_DD  PTADD_PTADD2          /* Data Direction switch 0 */
#endif
#ifdef SWITCH_TWO
   #define SWITCH_TWO_PE  PTEPE_PTEPE6        /* Pullup Enable switch 1 */
   #define SWITCH_TWO_DD  PTEDD_PTEDD6        /* Data Direction switch 1 */
#endif


/******************************* DON´T MODIFY ********************************/

/* Switch name relation */
#define SW_ONE      0
#define SW_TWO      1

/* Functions Prototypes */
void SwitchInit(void);
UINT8 SwitchStatus(UINT8 u8SwitchNumber);
```

6.1.3.1.4 DRIVERSKEYPAD.h

```
#include "driversMaster.h" /* Include peripheral declarations */


/*
 *   If you use a KBI interrupt in the pushButtons Init you need
 *   to put this code inthe KBI interrupt to reset the flag:
 *
 *       KBI_SC |= (0x01<<KBI_SC_ACK);
 */

/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */


/*
 * Comment the next line for disable KEYPAD functionality
 */
#define KEYPAD_EXISTS

/* Configuration of the keypad */
#define KEYPAD_CONF {             \
                {'1','2','3'},    \
                {'4','5','6'},    \
                {'7','8','9'},    \
                {'*','0','#'},    \
            }
```

```
/*
 * I/O pins used for the keypad configuration.
 * Comment the columns or rows that are unused.
 */
#define KEYPAD_OUT_ONE     PTCD_PTCD2      /* Output keypad column 1 */
#define KEYPAD_OUT_TWO    PTED_PTED5      /* Output keypad column 2 */
#define KEYPAD_OUT_THREE  PTCD_PTCD3      /* Output keypad column 3 */
//#define KEYPAD_IN_ONE   CMTOC_IROL      /* Input keypad row 1 */
#define KEYPAD_IN_TWO     PTED_PTED3      /* Input keypad row 2 */
#define KEYPAD_IN_THREE   PTED_PTED4      /* Input keypad row 3 */
#define KEYPAD_IN_FOUR    PTAD_PTAD5      /* Input keypad row 4 */

/*
 * Define the DDR for each calumn and row.
 * Comment the PE in case that not be applicable.
 */
#ifdef KEYPAD_OUT_ONE
    #define KEYPAD_OUT_ONE_DD   PTCDD_PTCDD2    /* DDR keypad column 1 */
#endif
#ifdef KEYPAD_OUT_TWO
    #define KEYPAD_OUT_TWO_DD   PTEDD_PTEDD5    /* DDR keypad column 2 */
#endif
#ifdef KEYPAD_OUT_THREE
    #define KEYPAD_OUT_THREE_DD PTCDD_PTCDD3    /* DDR keypad column 3 */
#endif
#ifdef KEYPAD_IN_ONE
    #define KEYPAD_IN_ONE_DD    PTCDD_PTCDD3    /* DDR keypad row 1 */
#endif
#ifdef KEYPAD_IN_TWO
    #define KEYPAD_IN_TWO_DD    PTEPE_PTEPE3    /* DDR keypad row 2 */
#endif
#ifdef KEYPAD_IN_THREE
    #define KEYPAD_IN_THREE_DD  PTEPE_PTEPE4    /* DDR keypad row 3 */
#endif
#ifdef KEYPAD_IN_FOUR
    #define KEYPAD_IN_FOUR_DD   PTAPE_PTAPE5    /* DDR keypad row 4 */
#endif


/*
 * Register and bits used to configurate the interrupt for keypad.
 * Comment KBI_EN_ADn to disable pins KBI interrupts.
 */
#ifndef KBI_EXISTS
    #define KBI_EXISTS                /* Comment for disable interrupt */
    #define KBI_SC        IRQSC       /* Interrupt Status and control register */
    #define KBI_SC_FLAG   3           /* Flag bit of KBI_SC */
    #define KBI_SC_ACK    2           /* Acknowledge bit of KBI_SC */
    #define KBI_SC_EN     1           /* Enable bit of KBI_SC */
    #define KBI_SC_MOD    0           /* Detection mode bit of KBI_SC */
    #define KBI_EN        IRQSC_IRQPE /* Enable interrupt in pin */
//    #define KBI_EN_AD1    KBIER_KBIE1 /* Enable interrupt in additional pin */
//    #define KBI_EN_AD2    KBIER_KBIE2 /* Enable interrupt in additional pin */
//    #define KBI_EN_AD3    KBIER_KBIE3 /* Enable interrupt in additional pin */
//    #define KBI_EN_AD4    KBIER_KBIE4 /* Enable interrupt in additional pin */
//    #define KBI_EN_AD5    KBIER_KBIE5 /* Enable interrupt in additional pin */
//    #define KBI_EN_AD6    KBIER_KBIE6 /* Enable interrupt in additional pin */
//    #define KBI_EN_AD7    KBIER_KBIE7 /* Enable interrupt in additional pin */
#endif
```

```
/******************************* DON´T MODIFY ********************************/

/* Functions Prototypes */
void KeypadInit(UINT8 u8UseKBI);      /* Initialize the Keypad */
UINT8 KeypadGetKey(void);             /* Return in ASCII the pressed key */
```

6.1.3.1.5 DRIVERSLEDS.h

```
#include "driversMaster.h" /* Include peripheral declarations */


/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/*
 * Comment the lines for disables Leds functionality
 */
#define LED_ONE         PTAD_PTAD3         /* Data led 0 */
#define LED_TWO         PTDD_PTDD0         /* Data led 1 */
#define LED_THREE       PTBD_PTBD2         /* Data led 2 */
#define LED_FOUR        PTCD_PTCD4         /* Data led 3 */
#define LED_FIVE        PTCD_PTCD5         /* Data led 4 */
#define LED_SIX         PTCD_PTCD6         /* Data led 5 */
#define LED_SEVEN       PTCD_PTCD7         /* Data led 6 */
//#define LED_EIGHT     PTDD_PTDD3         /* Data led 7 */

#ifdef LED_ONE
  #define LED_ONE_DD    PTADD_PTADD3           /* Data Direction led 0 */
#endif
#ifdef LED_TWO
  #define LED_TWO_DD    PTDDD_PTDDD0           /* Data Direction led 1 */
#endif
#ifdef LED_THREE
  #define LED_THREE_DD  PTBDD_PTBDD2           /* Data Direction led 2 */
#endif
#ifdef LED_FOUR
  #define LED_FOUR_DD   PTCDD_PTCDD4           /* Data Direction led 3 */
#endif
#ifdef LED_FIVE
  #define LED_FIVE_DD   PTCDD_PTCDD5           /* Data Direction led 4 */
#endif
#ifdef LED_SIX
  #define LED_SIX_DD    PTCDD_PTCDD6           /* Data Direction led 5 */
#endif
#ifdef LED_SEVEN
  #define LED_SEVEN_DD  PTCDD_PTCDD7           /* Data Direction led 6 */
#endif
#ifdef LED_EIGHT
  #define LED_EIGHT_DD  PTDDD_PTDDD3           /* Data Direction led 7 */
#endif



/******************************* DON´T MODIFY ********************************/

#define LED_ON    0   /* Value for led ON */
#define LED_OFF   1   /* Value for led OFF */

/* Led name relation */
#define LD_ONE    0   /* Led number 0 */
```

```
#define LD_TWO    1   /* Led number 1 */
#define LD_THREE  2   /* Led number 2 */
#define LD_FOUR   3   /* Led number 3 */
#define LD_FIVE   4   /* Led number 4 */
#define LD_SIX    5   /* Led number 5 */
#define LD_SEVEN  6   /* Led number 6 */
#define LD_EIGHT  7   /* Led number 7 */


/* Functions Prototypes */
void LedsInit(void);
void LedOn(UINT8 u8LedNumber);
void LedOff(UINT8 u8LedNumber);
void LedToggle(UINT8 u8LedNumber);
```

6.1.3.1.6 DRIVERSMASTER.h

```
/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/* Include peripheral declarations */
#ifndef MC9S08RG60_h
  #define MC9S08RG60_h
  #include "MC9S08RG60.h"
#endif

/* Time Base */
#define GTIME_BASE_INTERRUPT_EACH_US    200

/* Kind of MCU */
//#define MC908
#define MCS08

/******************************* DON´T MODIFY ********************************/

/* Data Types */
typedef unsigned char    UINT8;
typedef unsigned short   UINT16;
typedef unsigned long    UINT32;

/* This section contains values calculated from above data */
#define GTIME_BASE_INTERRUPT_PERMS    (1000/GTIME_BASE_INTERRUPT_EACH_US)
```

6.1.3.2 Source Code Files

6.1.3.2.1 MAIN.c

```
/******************************************************************************
*
*       Copyright (C) 2004 Motorola, Inc.
*       All Rights Reserved
*
* Filename:     $RCSfile: main.c,v $
* Author:       $Author: r29541 $
* Locker:       $Locker: r29541 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:    Romeo2 example, send msg with header
```

```
*
* History:
*
*
* Description: This is a demo that transmits a message with incrementing data
*              byte
*
*
*
* Notes:
*
*
****************************************************************************/
#include <hidef.h>      /* for EnableInterrupts macro                      */
#include "MC9S08RG60.h" /* include peripheral declarations                 */
#include "Tango.h"
#include "teamac.h"
#include "driversMaster.h"
#include "driversLeds.h"
#include "driversSwitch.h"
#include "driversKeypad.h"


UINT8 flagChar = 0;
UINT8 queChar;


extern unsigned char tangoTransmitBuffer[];


unsigned long TEAMAC_Data[2];
unsigned long TEAMAC_Code;
unsigned long cipherText[2];
unsigned long key[4];
unsigned char LastState;
unsigned char ActualState;

#pragma CONST_SEG TEAMAC_KEY
const unsigned char TEAMAC_Key[8]={0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08};
#pragma CONST_SEG DEFAULT


void main(void) {
    unsigned int i;
    unsigned char j;
    unsigned char count = 0;    /* Data byte sent in rf message*/

    SOPT= 3;                    /* Disable watchdog, enable reset pin,
                                 *  enable debug pin
                                 */

      /*Switch as input*/

     PTEDD_PTEDD6=0;
     PTEPE_PTEPE6=1;


  /* Outputs */

  /* Initialise DDR */
  PTCDD_PTCDD5 = 1;
  PTCDD_PTCDD6 = 1;
  PTCDD_PTCDD7 = 1;
```

```
/* Initialise LEDS to off */
PTCD_PTCD5 = 1;
PTCD_PTCD6 = 1;
PTCD_PTCD7 = 1;

  tangoTransmitBuffer[0] = 0x55;    /* Put message ID in tx buffer  */
  tangoTransmitBuffer[1] = 0x07;    /* Put data length in tx buffer */
  tangoTransmitBuffer[2] = 0x00;    /* Set data to 0                */
  tangoTransmitBuffer[3] = 0xFF; /* Set data to 0xFF, not a valid command */
  tangoTransmitBuffer[4] = 0x00;
  tangoTransmitBuffer[5] = 0x00;
  tangoTransmitBuffer[6] = 0x00;
  tangoTransmitBuffer[7] = 0x00;
  tangoTransmitBuffer[8] = 0x00;

  EnableInterrupts; /* Configures Tango driver using settings from Tango.H */
  TangoInitialise();/* This enables the Tango ic and starts 2ms delay      */
  TangoEnable();    /* (Tango ic needs 2ms to stabalise                    */


  KeypadInit(1);

  while(TangoDriverStatus() == TANGO_IN_ENABLE_DELAY){}
                                            /* Wait until end of 2ms delay */


  for (i = 0; i <= 10; i++)                 /* Send Preamble_ID 10 times   */
  {
      TangoSendPreamble_ID();
      while(TangoDriverStatus() != TANGO_READY ){}
                                           /* Wait until message gone      */
  }
  TangoSendData();                         /* Send data                    */
  while(TangoDriverStatus() != TANGO_READY ){}
                                           /* Wait until message gone      */
  TangoDisable();

LastState = 0;
ActualState = 0;

  /* Main loop - goes around this loop for each keypress */
  for (;;)
  {

    while ((LastState==PTED_PTED6) && (flagChar == 0)) {}
                                        /* Wait until actual state changes */
    for (i = 0; i< 0xff; i++) {}   /* Debounce loop               */
    if (flagChar == 1) {

            tangoTransmitBuffer[2] = ++count;/* Put data byte in tx buffer */
           tangoTransmitBuffer[3] = 0x03;
           tangoTransmitBuffer[4] = queChar;
           flagChar = 0;

    }
    else {
      LastState=PTED_PTED6;

      if ( PTED_PTED6 == 0)
      {
            PTCD_PTCD5 = ~PTCD_PTCD5;
            PTCD_PTCD6 = ~PTCD_PTCD6;
```

```
          PTCD_PTCD7 = ~PTCD_PTCD7;

         tangoTransmitBuffer[2] = ++count; /* Put data byte in tx buffer */
         tangoTransmitBuffer[3] = 0x00;
         tangoTransmitBuffer[4] = 0x00;

    }
    else if(PTED_PTED6 == 1)
        {

             PTCD_PTCD5 = ~PTCD_PTCD5;
             PTCD_PTCD6 = ~PTCD_PTCD6;
             PTCD_PTCD7 = ~PTCD_PTCD7;

            tangoTransmitBuffer[2] = ++count;/*Put data byte in tx buffer*/
            tangoTransmitBuffer[3] = 0x01;
            tangoTransmitBuffer[4] = 0x00;

        }

}

/* Start of TEAMAC algorithm */

TEAMAC_Data[0]=(unsigned long)tangoTransmitBuffer[2];
TEAMAC_Data[1]=(unsigned long)tangoTransmitBuffer[3];

char2Long(key, TEAMAC_Key);
char2Long(key+1, TEAMAC_Key+1);
char2Long(key+2, TEAMAC_Key+2);
char2Long(key+3, TEAMAC_Key+4);

encipher(TEAMAC_Data, cipherText, key);

TEAMAC_Code = cipherText[0] ^ cipherText[1];

Long2char(&tangoTransmitBuffer[5],&TEAMAC_Code);

  /* Endof TEAMAC algorithm */


TangoEnable();        /* This enables the Tango ic and starts 2ms delay  */

for (j=0;j<2;j++)

{
                      /* (Tango ic needs 2ms to stabalise)               */

      while(TangoDriverStatus() == TANGO_IN_ENABLE_DELAY){}
                                          /* Wait until end of 2ms delay */


      for ( i = 0; i <= 10; i++)          /* Send Preamble_ID 10 times   */
      {
          TangoSendPreamble_ID();
          while(TangoDriverStatus() != TANGO_READY ){}
                                          /* Wait until message gone     */
      }

      TangoSendData();                    /* Send Data                   */
      while(TangoDriverStatus() != TANGO_READY ){}
                                          /* Wait until message gone     */
    }

    TangoDisable();

    }
}

void interrupt 3 irqInterrupt(void) {
    UINT8 i;
    queChar = KeypadGetKey();
    if (queChar != 0) flagChar = 1;
    for (i = 255; i>0; i--) asm nop;
    KBI_SC |= (0x01<<KBI_SC_ACK);  // to reset the flag

}
```

6.1.3.2.2 TEAMAC.c

```
#include "teamac.h"

extern unsigned long TEAMAC_Data[2];
extern unsigned long TEAMAC_Code;
extern unsigned char TEAMAC_Key[8];

void char2Long(unsigned long *pDest,const unsigned char *pSrce)
{
  unsigned char bytes = 4;
  *pDest = 0;
  while (bytes--)
    {
    *pDest <<= 8;
    *pDest |= (*pSrce & 0xFF);
    *pSrce++;
    }
}

void Long2char(unsigned char *pDest,unsigned long *pSrce)
{
  unsigned char i;
  pDest+=3;
  for(i=0;i<4;i++)
  {
    *pDest = (unsigned char)(((*pSrce)>>(8*i)) & 0x000000FF);
    pDest--;

  }

}

void encipher(unsigned long *v, unsigned long *w,unsigned long *k)
{
  unsigned long y, z, sum, delta;
  unsigned char n;

  y=*v;
  z=*(v+1);
  sum=0;
  n=32;
  delta=0x9E3779B9;
  while(n-- > 0)
    {
    y += (((z << 4) ^ (z >> 5)) + z) ^ (sum + k[sum&3]);
    sum += delta;
    z += (((y << 4) ^ (y >> 5)) + y) ^ (sum + k[(sum>>11) & 3]);
    }
  w[0]=y; w[1]=z;
}
```

6.1.3.2.3 TANGO.c

```
/******************************************************************************
*
*       Copyright (C) 2004 Motorola, Inc.
*       All Rights Reserved
*
* Filename:     $RCSfile: Tango.c,v $
* Author:       $Author: r29541 $
* Locker:       $Locker: r29541 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:    Tango3 software driver for HCS08
*
* History:
*
*
* Description:   This is C code for Tango3 software driver for HCS08
*
*
*
* Notes:
*
******************************************************************************/


#include "tango.h"          /* Include driver header file */



unsigned char tangoDriverState;


unsigned char bitCounter; /*bits in current byte remaining                  */
unsigned char byteCounter;/*number of bytes remaining to send               */
unsigned char data;        /*local data store (so that message buffer contents*/
                          /*not corrupted)                                  */
                          /* Counter used for 2 ms delay when part enabled   */
unsigned char enableDelayCounter;

unsigned char * ptrData;/* pointer used to retrieve data from message buffer*/

tTANGO_STATUS status;    /* contains status flags                           */

unsigned char tangoTransmitBuffer[TANGO_MAX_DATA_SIZE+2];
                          /*  Data buffer for holding message
                              Format of buffer is :-
                              ID byte
                              Data Length Byte - note this length excludes
                                                 the ID byte !!
                              Data MSB
                              ...
                              ...
                              Data LSB

                              Format of control/length byte

                              Bits 7-4, not used
                              Bits 3-0, message length
                          */






/* Send preamble, header, then data, then EOM */
void TangoSendData(void)
{
  volatile unsigned char temp;
    status.Bits.eomFlag = 1;
    status.Bits.busy = 1;

    TangoCalculateChecksum();          /* Add checksum to message             */
    ptrData = &tangoTransmitBuffer[1];/* Point to 1st databyte in msg buffer */
    byteCounter = tangoTransmitBuffer[1]+3;/* Add 1 byte for header transfer,*/
                                      /*      1 for length, 1 for checksum   */

    #if TANGO_MODE_VALUE == TANGO_FSK  /*  If FSK modulation                  */
      data = TANGO_FSK_HEADER;        /* Schedule 4bit preamble + 4bit header*/
      bitCounter = 8;
      tangoDriverState = TANGO_SEND_BYTE;
      TANGO_TPMxCxVH = TANGO_COMH;
      TANGO_TPMxCxVL  = TANGO_COML;    /* Set O/C to 1/2 modulus              */
      TANGO_TPMxCxSC = 0x58;          /* O/C, clear on compare               */
    #else                              /* else if OOK modulation              */
      data = TANGO_OOK_HEADER;        /* First byte to be sent will be header*/
      bitCounter = 4;                  /* Header uses 4 bits                  */
      tangoDriverState = TANGO_START;
      TANGO_TPMxCxVH = TANGO_MODH;
      TANGO_TPMxCxVL = TANGO_MODL;    /* Set O/C to = modulus                */
      temp = TANGO_TPMxCxSC;
      TANGO_TPMxCxSC = 0x18;          /* O/C clear on compare                */
                                      /* (clears pending interrupt)          */
      TANGO_TPMxCxSC = 0x5c;          /* O/C, set on compare                 */
    #endif // TANGO_MODE = TANGO_FSK
    TANGO_TPMxSC = TANGO_TPMxSC | TANGO_TIMER_ON;
        asm cli;                      /* Enable Interrupts                   */
}


/* Send preamble , then ID)  */
void TangoSendPreamble_ID(void)
{
volatile unsigned char temp;
       status.Bits.eomFlag = 0;
       status.Bits.busy = 1;

    #if TANGO_MODE_VALUE == TANGO_FSK  /* If  FSK modulation                  */
      ptrData = &tangoTransmitBuffer[0];/*Point to ID byte in message buffer */
      byteCounter = 2;               /* One byte for preamble, 1 for ID,     */
      bitCounter= 4;                 /* Preamble uses 4 bits                 */
      data = 0;                       /* Preload data with preamble (4 zeroes)*/
      tangoDriverState = TANGO_SEND_BYTE;
      TANGO_TPMxCxVH = TANGO_COMH;
      TANGO_TPMxCxVL = TANGO_COML;   /* Set O/C to 1/2 modulus               */
      TANGO_TPMxCxSC = 0x58;         /* O/C, clear on compare                */
    #else                             /* else if OOK modulation               */
      data = tangoTransmitBuffer[0]; /* Copy ID to global variable           */
      byteCounter = 1;
      bitCounter = 8;
      tangoDriverState = TANGO_START;
      TANGO_TPMxCxVH = TANGO_MODH;
      TANGO_TPMxCxVL = TANGO_MODL;   /* Set O/C to = modulus                 */
      temp = TANGO_TPMxCxSC;
      TANGO_TPMxCxSC = 0x18;         /* O/C clear on compare                 */
                                     /* (clears pending interrupt)           */
      TANGO_TPMxCxSC = 0x5c;         /* O/C, set on compare                  */
    #endif

    TANGO_TPMxSC = TANGO_TPMxSC | TANGO_TIMER_ON;  /* Start timer             */
                                                  /* (if not already running */
        asm cli;
}


/* Send message with no header                    */
/* Format: Preamble,  ID (x idRepeat), data, EOM  */
void TangoSendMessageNoHeader( unsigned char idRepeat)
{
volatile unsigned char temp;

  status.Bits.eomFlag = 1;
  status.Bits.busy = 1;
  TangoCalculateChecksum();             /* Add checksum to message             */
  ptrData = &tangoTransmitBuffer[0];  /* Point to ID byte in message buffer  */
  #if TANGO_MODE_VALUE == TANGO_FSK    /* If FSK modulation                   */
    data = TANGO_FSK_HEADER;
    bitCounter = 4;                               /*  4 bits for preamble     */
    byteCounter = tangoTransmitBuffer[1] + idRepeat+4;
                                                 /* Add number of ID repeats */
                                                 /* +4 for ID, preamble,     */
                                                 /* length byte, checksum    */
    tangoDriverState = TANGO_SEND_BYTE;
    TANGO_TPMxCxVH = TANGO_COMH;
    TANGO_TPMxCxVL = TANGO_COML;                 /* Set O/C to 1/2 modulus   */
    TANGO_TPMxCxSC = 0x58;                       /* O/C, clear on compare    */
  #else                                           /* else if OOK modulation   */
    data = *ptrData++;                           /* First byte to be sent    */
                                                 /* will be ID               */
    bitCounter = 8;                               /* ID byte uses 8 bits      */
    byteCounter = tangoTransmitBuffer[1] + idRepeat+3;
                                                 /* Add number of ID repeats */
                                                 /* +3 for ID, length byte,  */
                                                 /* checksum                 */
    tangoDriverState = TANGO_START;
    TANGO_TPMxCxVH = TANGO_MODH;
    TANGO_TPMxCxVL = TANGO_MODL;                 /* Set O/C to = modulus     */
    temp = TANGO_TPMxCxSC;
    TANGO_TPMxCxSC = 0x18;                       /* O/C clear on compare     */
                                                 /* clears pending interrupt)*/
    TANGO_TPMxCxSC = 0x5c;                       /* O/C, set on compare      */
  //}
  #endif

    TANGO_TPMxSC = TANGO_TPMxSC | TANGO_TIMER_ON;/* Start timer              */
                                                 /* (if not already running) */
    asm cli;
}


interrupt void TangoTimerInterrupt(void)
{
volatile unsigned char temp;

  temp = TANGO_TPMxCxSC;                         /* Read ch1 flag            */
  switch (tangoDriverState)
  {


    case TANGO_ENABLE_DELAY:

            if (--enableDelayCounter == 0)
            {
              status.Bits.enableDelay = 0;
                        TANGO_TPMxCxSC = 0x18;       /* Disable channel int, */
                                                     /* o/c clear            */
                            #ifdef TANGO_TIMER_CLK_IN_CHANNEL
                                                     /* If using ext clock   */
                               TANGO_TPMxMODH = TANGO_MODH;
                                                      /* Load modulus with bit*/
                                                      /* timing values        */
                              TANGO_TPMxMODL = TANGO_MODL;
                          #endif
                        break;
            }
            else
            {
              TANGO_TPMxCxSC = 0x58;                 /* O/C clear            */
                break;
            }
    case TANGO_START:
            TANGO_TPMxCxVH = TANGO_COMH;
            TANGO_TPMxCxVL = TANGO_COML;           /* Set O/C to 1/2 modulus */
            tangoDriverState = TANGO_PREAMBLE_1;
            TANGO_TPMxCxSC = 0x5c;                 /* Clears int flag        */
            break;
    case TANGO_PREAMBLE_1:
            tangoDriverState = TANGO_PREAMBLE_2;
            TANGO_TPMxCxSC = 0x5c;                 /* Clears int flag */
            break;
    case TANGO_PREAMBLE_2:
            tangoDriverState = TANGO_SEND_BYTE;
            TANGO_TPMxCxSC = 0x64;                 /* PWM , low true pulses  */
                                                  /*( _|- Manchester output )*/
            break;

    case TANGO_SEND_BYTE:
            if (bitCounter == 0)
            {
              byteCounter--;
              if (byteCounter == 0)                /* If last byte, then add  */
                                                  /* extra bit               */
              {
                tangoDriverState = TANGO_EXTRA_BIT;
                TANGO_TPMxCxSC = 0x64;            /* PWM , low true pulses   */
```

```
                                              /*( _|- Manchester output )*/
            break;
          }
          else                                /* byteCounter != 0        */
          {
           #if TANGO_MODE_VALUE == TANGO_FSK
              if (byteCounter > tangoTransmitBuffer[1]+3)  /*If ID repeat*/
           #else
            if (byteCounter > tangoTransmitBuffer[1]+2)    /*If ID repeat*/
          #endif
            {
              data = tangoTransmitBuffer[0];               /* Data = ID  */
            }
            else
            {
              data = *ptrData++;             /* Get next byte to send    */
            }
            bitCounter = 8;
          }
        }
                                         /* if bitCounter != 0           */
        if  ( (data & 0x80) == 0)         /* if MSB = 0                  */
        {
          TANGO_TPMxCxSC = 0x64;         /* PWM , low true pulses        */
                                         /* ( _|-  Manchester output )   */
        }
        else                             /* if MSB = 1                   */
        {
          TANGO_TPMxCxSC = 0x68;         /* PWM, high true pulses        */
                                         /* (-|_  Manchester output)     */
        }
        bitCounter--;
        data = data << 1;                 /* Shift data by 1 bit           */
        break;


case  TANGO_EXTRA_BIT:
        if (status.Bits.eomFlag == 1)     /* if require eom               */
        {
          tangoDriverState = TANGO_EOM_1;
        }
        else
        {
          tangoDriverState = TANGO_END;
        }
        TANGO_TPMxCxSC = 0x58;           /* O/C ,clear on match          */
        TANGO_TPMxCxVH = TANGO_MODH;
        TANGO_TPMxCxVL = TANGO_MODL;     /* Set compare to == modulus    */
        break;
case   TANGO_EOM_1:
        tangoDriverState = TANGO_EOM_2;
        TANGO_TPMxCxSC = 0x58;           /* O/C , clear on match */
        break;
case   TANGO_EOM_2:
        tangoDriverState = TANGO_END;
        TANGO_TPMxCxSC = 0x58;           /* O/C , clear on match */
        break;
case   TANGO_END:
        status.Bits.eomFlag = 0;
        status.Bits.busy = 0;
                  TANGO_TPMxCxSC = 0x18;/* Disable channel int, o/c clear*/
        #if TANGO_TIMER_DISABLE == 1
          TANGO_TPMxSC = TANGO_TPMxSC & TANGO_TIMER_OFF; /*Turn off timer*/
```

```
                                                             /* if required  */
            #endif
    default:    break;
  }
}


/* Initialise the timer channel and tango       */
/* Note Tango is not power on by this function  */
/* Use TangoEnable to power up Tango            */

void TangoInitialise(void)
{
/* Setup Tango */
#ifdef TANGO_MODE
  #if TANGO_MODE_VALUE == TANGO_OOK
     TANGO_MODE = 0;
  #else
     TANGO_MODE = 1;
  #endif

  TANGO_MODE_DDR = 1;
#endif

#ifdef TANGO_BAND
  TANGO_BAND = TANGO_BAND_VALUE;
  TANGO_BAND_DDR = 1;
#endif

#ifdef TANGO_ENABLE
  TANGO_ENABLE = 0;
  TANGO_ENABLE_DDR = 1;                              /* Tango is not enabled  */
#endif

#ifdef TANGO_ENABLE_PA
    TANGO_ENABLE_PA_DDR = 1;
    TANGO_ENABLE_PA = 0;
#endif

  status.Byte = 0;                                  /* Reset flags           */

#ifdef TANGO_TIMER_CLK_IN_CHANNEL                /* If using external clock  */
    TANGO_TPMxMODH  = TANGO_2MS_EXT_H;/* Load modulus with 2ms timeout value */
    TANGO_TPMxMODL  = TANGO_2MS_EXT_L;
#else                                 /* If using internal clock             */
  TANGO_TPMxMODH = TANGO_MODH;        /* Load modulus with bit timing values */
  TANGO_TPMxMODL = TANGO_MODL;
#endif
}


/* Powers up Tango and schedules 2 ms startup delay */
void TangoEnable(void)
{
#ifdef TANGO_ENABLE
    TANGO_ENABLE = 1;
#endif

#ifdef TANGO_ENABLE_PA
        TANGO_ENABLE_PA = 1;            /* BUG !! missing semicolon */
#endif
       status.Bits.enabled = 1;
    status.Bits.enableDelay = 1;
```

```
        #ifdef TANGO_TIMER_CLK_IN_CHANNEL           /* If using ext clock    */
            enableDelayCounter = 1;
            TANGO_TPMxCxVH = TANGO_2MS_EXT_H;
            TANGO_TPMxCxVL = TANGO_2MS_EXT_L;       /* Set for 2 ms delay    */
        #else                                       /* If using int clock    */
            enableDelayCounter = TANGO_2MS_DELAY;
        TANGO_TPMxCxVH = TANGO_MODH;
        TANGO_TPMxCxVL = TANGO_MODL;          /* Set O/C to = modulus        */
        #endif

        #ifdef TANGO_TIMER_CLK_IN_CHANNEL        /* If using external clock  */
            TANGO_TPMxMODH  = TANGO_2MS_EXT_H;   /* Load modulus with 2ms
                                                  *   timeout value
                                                  */
            TANGO_TPMxMODL  = TANGO_2MS_EXT_L;
        #else                                 /* If using internal clock     */
          TANGO_TPMxMODH = TANGO_MODH; /*Load modulus with bit timing values */
          TANGO_TPMxMODL = TANGO_MODL;
        #endif

    TANGO_TPMxCxSC = 0x18;                       /* O/C clear on compare     */
                                                 /* clears pending interrupt)*/
    TANGO_TPMxCxSC = 0x58;                       /* O/C , clear on match     */
    tangoDriverState = TANGO_ENABLE_DELAY;

    TANGO_TPMxSC = TANGO_TPMxSC | TANGO_TIMER_ON;  /* Start timer             */
                                                  /* (if not already running)*/
       asm cli
}


/* Disables Tango */
void TangoDisable(void)
{

#ifdef TANGO_ENABLE
    TANGO_ENABLE = 0;
#endif
       status.Bits.enabled = 0;
     TANGO_TPMxCxSC = 0x18;                 /* Disable channel int, o/c clear */

#if  TANGO_TIMER_DISABLE  == 1
    TANGO_TPMxSC = TANGO_TPMxSC & TANGO_TIMER_OFF;/*Turn off timer if required*/
#endif
}



/* Return current status of the driver  */
/* TANGO_DISABLED   disabled */
/* TANGO_IN_ENABLE_DELAY  - waiting for 2ms delay */
/* TANGO_READY  */
/* TANGO_BUSY - sending message */

unsigned char TangoDriverStatus(void)
{
  if (0 == status.Bits.enabled)                    /* If tango disabled       */
    return TANGO_DISABLED;
  else if (1 == status.Bits.enableDelay)          /* If in 2ms delay         */
    return TANGO_IN_ENABLE_DELAY;
  else if (0 == status.Bits.busy)                  /* else if not busy        */
    return TANGO_READY;
  else
      return TANGO_BUSY;
}


/* Append a checksum on to message */
void TangoCalculateChecksum(void)
{
  unsigned char temp;
    asm
    {
      PSHA
     PSHX
        LDA *( @tangoTransmitBuffer +1)
        ADD #$02        ;Add ID, length
        STA temp
        CLRA

        CLC
        LDHX  @tangoTransmitBuffer
     loop:        ;Calculate checksum
        ADC    ,X
        AIX    #$01
        DEC    temp
        BNE   loop
        ADC    #0    ; Add final carry
        COMA
        STA     ,X    ;Append on to message
        PULX
        PULA
    }
}
```

6.1.3.2.4 START08.c

```
/*******************************************************************************
  FILE        : start08.c
  PURPOSE     : 68HC08 standard startup code
  LANGUAGE    : ANSI-C / INLINE ASSEMBLER
  ----------------------------------------------------------------------------
  HISTORY
    22 oct 93         Created.
    04/17/97          Also C++ constructors called in Init().
 ******************************************************************************/

#include <start08.h>

/***********************************************************************/
#pragma DATA_SEG FAR _STARTUP
struct _tagStartup _startupData;    /* read-only:
                                     _startupData is allocated in ROM and
                                     initialized by the linker */


#define USE_C_IMPL 0 /* for now, we are using the inline assembler implementation for the
startup code */

#if !USE_C_IMPL
#pragma MESSAGE DISABLE C20001 /* Warning C20001: Different value of stackpointer depending on
control-flow */
```

```
/* the function _COPY_L releases some bytes from the stack internally */

#ifdef __OPTIMIZE_FOR_SIZE__
#pragma NO_ENTRY
#pragma NO_EXIT
#pragma NO_FRAME
/*lint -esym(528, loadByte) inhibit warning about not referenced loadByte function */
static void near loadByte(void) {
  asm {
             PSHH
             PSHX
#ifdef __HCS08__
             LDHX    5,SP
             LDA     0,X
             AIX     #1
             STHX    5,SP
#else
             LDA     5,SP
             PSHA
             LDX     7,SP
             PULH
             LDA     0,X
             AIX     #1
             STX     6,SP
             PSHH
             PULX
             STX     5,SP
#endif
             PULX
             PULH
             RTS
  }
}
#endif /* __OPTIMIZE_FOR_SIZE__ */

#endif

/*lint -esym(752,_COPY_L)  inhibit message on dunction declared, but not used (it is used in
HLI) */
extern void _COPY_L(void);
/* DESC:    copy very large structures (>= 256 bytes) in 16 bit address space (stack incl.)
   IN:      TOS count, TOS(2) @dest, H:X @src
   OUT:
   WRITTEN: X,H */
#ifdef __ELF_OBJECT_FILE_FORMAT__
  #define toCopyDownBegOffs 0
#else
  #define toCopyDownBegOffs 2 /* for the hiware format, the toCopyDownBeg field is a long.
Because the HC08 is big endian, we have to use an offset of 2 */
#endif
static void Init(void) {
/* purpose:     1) zero out RAM-areas where data is allocated
                2) init run-time data
                3) copy initialization data from ROM to RAM
 */
  /*lint -esym(529,p,i)  inhibit warning about symbols not used: it is used in HLI below */
  int i;
  int *far p;
  /*lint +e529 */
#if USE_C_IMPL   /* C implementation of ZERO OUT and COPY Down */
  int j;
  char *dst;
  _Range *far r;
  r = _startupData.pZeroOut;

  /* zero out */
  for (i=0; i != _startupData.nofZeroOuts; i++) {
    dst = r->beg;
    j = r->size;
    do {
      *dst = 0; /* zero out */
      dst++;
      j--;
    } while(j != 0);
    r++;
  }
#else /* faster and smaller asm implementation for ZERO OUT */
  asm {
ZeroOut:      ;
              LDA    _startupData.nofZeroOuts:1 ; nofZeroOuts
              INCA
              STA    i:1                        ; i is counter for number of zero outs
              LDA    _startupData.nofZeroOuts:0 ; nofZeroOuts
              INCA
              STA    i:0
              LDHX   _startupData.pZeroOut      ; *pZeroOut
              BRA    Zero_5
Zero_3:     ;
             ; CLR    i:1 is already 0
Zero_4:     ;
              ; { HX == _pZeroOut }
              PSHX
              PSHH
              ; { nof bytes in (int)2,X }
              ; { address in (int)0,X   }
              LDA    0,X
              PSHA
              LDA    2,X
              INCA
              STA    p                  ; p:0 is used for high byte of byte counter
              LDA    3,X
              LDX    1,X
              PULH
              INCA
              BRA    Zero_0
Zero_1:     ;
            ;  CLRA   A is already 0, so we do not have to clear it
Zero_2:     ;
              CLR    0,X
              AIX    #1
Zero_0:     ;
              DBNZA  Zero_2
Zero_6:
              DBNZ   p, Zero_1
              PULH
              PULX                            ; restore *pZeroOut
              AIX    #4                       ; advance *pZeroOut
Zero_5:     ;
              DBNZ   i:1, Zero_4
              DBNZ   i:0, Zero_3
              ;
CopyDown:     ;

  }
```

```
#endif

  /* copy down */
  /* _startupData.toCopyDownBeg  --->  {nof(16) dstAddr(16) {bytes(8)}^nof} Zero(16) */
#if USE_C_IMPL /* (optimized) C implementation of COPY DOWN */
  p = (int*far)_startupData.toCopyDownBeg;
  for (;;) {
    i = *p; /* nof */
    if (i == 0) {
      break;
    }
    dst = (char*far)p[1]; /* dstAddr */
    p+=2;
    do {
      /* p points now into 'bytes' */
      *dst = *((char*far)p); /* copy byte-wise */
      ((char*far)p)++;
      dst++;
      i--;
    } while (i!= 0);
  }
#elif defined(__OPTIMIZE_FOR_SIZE__)
  asm {
#ifdef __HCS08__
             LDHX   _startupData.toCopyDownBeg:toCopyDownBegOffs
             PSHX
             PSHH
#else
             LDA    _startupData.toCopyDownBeg:(1+toCopyDownBegOffs)
             PSHA
             LDA    _startupData.toCopyDownBeg:(0+toCopyDownBegOffs)
             PSHA
#endif
Loop0:
             JSR    loadByte  ; load high byte counter
             TAX              ; save for compare
             INCA
             STA    i
             JSR    loadByte  ; load low byte counter
             INCA
             STA    i:1
             DECA
             BNE    notfinished
             CBEQX  #0, finished
notfinished:

             JSR    loadByte  ; load high byte ptr
             PSHA
             PULH
             JSR    loadByte  ; load low byte ptr
             TAX              ; HX is now destination pointer
             BRA    Loop1
Loop3:
Loop2:
             JSR    loadByte  ; load data byte
             STA    0,X
             AIX    #1
Loop1:
             DBNZ   i:1, Loop2
             DBNZ   i:0, Loop3
             BRA    Loop0

finished:
```

```
             AIS #2
    };
#else /* optimized asm version. Some bytes (ca 3) larger than C version (when considering the
runtime routine too), but about 4 times faster */
  asm {
#ifdef __HCS08__
             LDHX   _startupData.toCopyDownBeg:toCopyDownBegOffs
#else
             LDX    _startupData.toCopyDownBeg:(0+toCopyDownBegOffs)
             PSHX
             PULH
             LDX    _startupData.toCopyDownBeg:(1+toCopyDownBegOffs)
#endif
next:
             LDA   0,X    ; list is terminated by 2 zero bytes
             ORA   1,X
             BEQ copydone
             PSHX         ; store current position
             PSHH
             LDA   3,X    ; psh dest low
             PSHA
             LDA   2,X    ; psh dest high
             PSHA
             LDA   1,X    ; psh cnt low
             PSHA
             LDA   0,X    ; psh cnt high
             PSHA
             AIX   #4
             JSR  _COPY_L ; copy one block
             PULH
             PULX
             TXA
             ADD   1,X    ; add low
             PSHA
             PSHH
             PULA
             ADC   0,X    ; add high
             PSHA
             PULH
             PULX
             AIX   #4
             BRA next
copydone:
  };
#endif


  /* FuncInits: for C++, this are the global constructors */
#ifdef __cplusplus
#ifdef __ELF_OBJECT_FILE_FORMAT__
  i = (int)(_startupData.nofInitBodies - 1);
  while ( i >= 0) {
    (&_startupData.initBodies->initFunc)[i]();  /* call C++ constructors */
    i--;
  }
#else
  if (_startupData.mInits != NULL) {
    _PFunc *fktPtr;
    fktPtr = _startupData.mInits;
    while(*fktPtr != NULL) {
      (**fktPtr)(); /* call constructor */
      fktPtr++;
    }
  }
#endif
#endif
  /* LibInits: used only for ROM libraries */
}

#pragma NO_EXIT
#ifdef __cplusplus
  extern "C"
#endif
void _Startup (void) { /* To set in the linker parameter file: 'VECTOR 0 _Startup' */
/*  purpose:    1)  initialize the stack
                2)  initialize run-time, ...
                    initialize the RAM, copy down init dat etc (Init)
                3)  call main;
    called from: _PRESTART-code generated by the Linker
*/
#ifdef __ELF_OBJECT_FILE_FORMAT__
  DisableInterrupts;  /* in HIWARE format, this is done in the prestart code */
#endif
  for (;;) { /* forever: initialize the program; call the root-procedure */
    if (!(_startupData.flags&STARTUP_FLAGS_NOT_INIT_SP)) {
      /* initialize the stack pointer */
      INIT_SP_FROM_STARTUP_DESC();
    }
    Init();
    (*_startupData.main)();
  } /* end loop forever */
}
```

6.1.3.2.5 DRIVERSSWITCH.c

Same as 6.2.1.2.9 DRIVERSSWITCH.c

6.1.3.2.6 DRIVERSKEYPAD.c

```
#include "driversKeyPad.h"

const cKeypad[][3]  = KEYPAD_CONF;

/* Keypad Driver */
#ifdef KEYPAD_EXISTS

   /* Initialize keypad */
   void KeypadInit(UINT8 u8UseKBI) {

      /* Set pins to input */
      #ifdef KEYPAD_OUT_ONE
         KEYPAD_OUT_ONE_DD =    1;
         KEYPAD_OUT_ONE =       0;
      #endif
      #ifdef KEYPAD_OUT_TWO
         KEYPAD_OUT_TWO_DD =    1;
         KEYPAD_OUT_TWO =       0;
      #endif
      #ifdef KEYPAD_OUT_THREE
         KEYPAD_OUT_THREE_DD =  1;
         KEYPAD_OUT_THREE =     0;
      #endif
      #ifdef KEYPAD_IN_ONE
         KEYPAD_IN_ONE_DD =     0;
      #endif
      #ifdef KEYPAD_IN_TWO
         KEYPAD_IN_TWO_DD =     0;
      #endif
      #ifdef KEYPAD_IN_THREE
         KEYPAD_IN_THREE_DD =   0;
      #endif
      #ifdef KEYPAD_IN_FOUR
         KEYPAD_IN_FOUR_DD =    0;
      #endif

      #ifdef KBI_EXISTS
         if (u8UseKBI) {
            KBI_SC &= ~(0x01<<KBI_SC_MOD);
            #ifdef MC908
               KBI_SC &= ~(0x01<<KBI_SC_EN);
            #else
               KBI_SC |= (0x01<<KBI_SC_EN);
            #endif
            KBI_EN = 1;
            #ifdef KBI_EN_AD1
               KBI_EN_AD1 = 1;
            #endif
            #ifdef KBI_EN_AD2
               KBI_EN_AD2 = 1;
            #endif
            #ifdef KBI_EN_AD3
               KBI_EN_AD3 = 1;
            #endif
            #ifdef KBI_EN_AD4
               KBI_EN_AD4 = 1;
            #endif
            #ifdef KBI_EN_AD5
               KBI_EN_AD5 = 1;
            #endif
            #ifdef KBI_EN_AD6
               KBI_EN_AD6 = 1;
            #endif
            #ifdef KBI_EN_AD7
               KBI_EN_AD7 = 1;
            #endif
         }
      #endif
   }

   /* KeyPad get key */
   UINT8 KeypadGetKey(void) {

      UINT8 u8Row = 0;
      UINT8 u8Col = 0;
      UINT8 u8In;
      #ifdef KEYPAD_OUT_ONE
         KEYPAD_OUT_ONE_DD = 1;
         #ifdef KEYPAD_OUT_TWO
            KEYPAD_OUT_TWO_DD = 0;
            #ifdef KEYPAD_OUT_THREE
               KEYPAD_OUT_THREE_DD = 0;
            #endif
         #else
            #ifdef KEYPAD_OUT_THREE
               KEYPAD_OUT_THREE_DD = 0;
            #endif
         #endif
```

```
#else
   #ifdef KEYPAD_OUT_TWO
      KEY_PAD_OUT_TWO_DD = 1;
      u8Col = 1;
      #ifdef KEYPAD_OUT_THREE
         KEYPAD_OUT_THREE_DD = 0;
      #endif
   #else
      #ifdef KEYPAD_OUT_THREE
         KEYPAD_OUT_THREE_DD = 1;
         u8Col = 2;
      #else
         u8Col = 3;
      #endif
   #endif
#endif
#ifdef KEYPAD_OUT_ONE
   KEYPAD_OUT_ONE = 0;
#else
  #ifdef KEYPAD_OUT_TWO
    KEYPAD_OUT_TWO = 0;
  #else
    #ifdef KEYPAD_OUT_THREE
       KEYPAD_OUT_THREE = 0;
     #endif
  #endif
#endif
while (u8Col<3) {
   u8In = 0xFF;
   #ifdef KEYPAD_IN_ONE
     u8In -= !KEYPAD_IN_ONE;
   #endif
   #ifdef KEYPAD_IN_TWO
     u8In -= ((!KEYPAD_IN_TWO)*2);
   #endif
   #ifdef KEYPAD_IN_THREE
     u8In -= ((!KEYPAD_IN_THREE)*4);
   #endif
   #ifdef KEY_PAD_IN_FOUR
     u8In -= ((!KEY_PAD_IN_FOUR)*8);
   #endif
  if (u8In < 0xFF) {
      u8In = ~ u8In;
      while ((u8In>1) && (u8Row<4)) {
        u8In <<= 1;
        u8Row++;
      }
      break;
  } else {
    u8Col++;
    #ifdef KEY_PAD_OUT_ONE_DD
       if (KEY_PAD_OUT_ONE_DD) {
            KEY_PAD_OUT_ONE_DD = 0;
            #ifdef KEYPAD_OUT_TWO
               KEY_PAD_OUT_TWO_DD = 1;
               #ifdef KEYPAD_OUT_THREE
                  KEYPAD_OUT_THREE_DD = 0;
               #endif
               KEYPAD_OUT_TWO = 0;
            #else
               #ifdef KEYPAD_OUT_THREE
                  KEYPAD_OUT_THREE_DD = 1;
               #endif
```

```
                     u8Col++;
                  #endif
               }
               else
               {
                  KEY_PAD_OUT_ONE_DD = 0;
                  #ifdef KEYPAD_OUT_TWO
                     KEY_PAD_OUT_TWO_DD = 0;
                     #ifdef KEYPAD_OUT_THREE
                        KEYPAD_OUT_THREE_DD = 1;
                        KEYPAD_OUT_THREE = 0;
                     #endif
                  #else
                     #ifdef KEYPAD_OUT_THREE
                        KEYPAD_OUT_THREE_DD = 1;
                        KEYPAD_OUT_THREE = 0;
                     #endif
                  #endif
               }
            #else
               #ifdef KEYPAD_OUT_TWO
                  KEYPAD_OUT_TWO_DD = 0;
                  #ifdef KEYPAD_OUT_THREE
                     KEYPAD_OUT_THREE_DD = 1;
                     KEYPAD_OUT_THREE = 0;
                  #endif
               #else
                  #ifdef KEYPAD_OUT_THREE
                     KEYPAD_OUT_THREE_DD = 1;
                     KEYPAD_OUT_THREE = 0;
                  #endif
               #endif
            #endif
        }
      }
      KeypadInit(0);
      if ((u8Col<3) && (u8Row<4)) {
        return (cKeypad[u8Row][u8Col]);
      }
      else {
        return (0);
      }
   }

#endif
/* END Keypad Driver */
```

6.1.3.2.7 DRIVERSLEDS.c

Same as 6.2.1.2.7 DRIVERSLEDS.c

6.2 HOME Connectivity Demo

6.2.1 HOMEdemoAP64Rx1, HOMEdemoAP64Rx2

There is only one difference between the receivers. This is the `ROMEO_ID_VALUE` in the ROMEO.h

6.2.1.1 Include Files

6.2.1.1.1 TEAMAC.h

```
#ifndef teamac_h
#define teamac_h

void char2Long(unsigned long *pDest,const unsigned char *pSrce);
void Long2char(unsigned char *pDest,unsigned long *pSrce);
void encipher(unsigned long *v, unsigned long *w,unsigned long *k);

#endif
```

6.2.1.1.2 ROMEO.h

```
#ifndef ROMEO_H
#define ROMEO_H
/******************************************************************************
*
*       Copyright (C) 2004 Motorola, Inc.
*       All Rights Reserved
*
* Filename:     $RCSfile: Romeo.h,v $
* Author:       $Author: r29541 $
* Locker:       $Locker: r29541 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:   Romeo2 software driver header file for HC08
*
* History:
*
*
* Description: This is header file for Romeo2 software driver for HC08
*
*
*
*
* Notes:
*
******************************************************************************/

#define ROMEO_OOK  0
#define ROMEO_FSK  1

/*****************************************************************************/
/*            THIS SECTION CONTAINS VALUES YOU MUST DEFINE!                  */
/*****************************************************************************/
#include "MC68HC908AP64.h"                /* include peripheral declarations */

/* Specify start adress of SPI registers                                     */
#define ROMEO_SPI_ADDRESS   0x10          /* Address varies from mcu to mcu  */

/* Set length of data field in receive data buffers                          */
#define ROMEO_MAX_DATA_SIZE 12            /* Max length of data field in msg */

/* Set Romeo reset pin                                                       */
#define ROMEO_RESET         PTD_PTD3      /* Define pin used for Reset       */
#define ROMEO_RESET_DDR     DDRD_DDRD3
```

```
/* Set Romeo mode                                                            */
#define ROMEO_MODE_VALUE    ROMEO_OOK    /* ROMEO_OOK = OOK reception        */
                                         /* ROMEO_FSK = FSK reception        */
/* Set Romeo band                                                             */
#define ROMEO_BAND_VALUE    1            /* 0 = lower band (315MHz)          */
                                         /* 1 = higher band (434MHz, 868MHz) */
/* Enable/disable Strobe osc                                                 */
#define ROMEO_SOE_VALUE     1            /* 0 = strobe oscillator disabled   */
                                         /* 1 = strobe oscillator enabled     */

/* Header word present select                                                 */
#define ROMEO_HE_VALUE      1            /* 0 = No header word used           */
                                         /* 1 = Header word present           */

/* Define ID word value                                                      */
#define ROMEO_ID_VALUE      0x10         /* ID word recognised by Romeo
                                          * Use the 0x20 value for the other
                                          *    receiver.
                                          */

/* SPI clock speed                                                           */
#define ROMEO_SPI_CLOCK_SPEED   9830400

/* Strobe Ratio value                                                        */
#define ROMEO_SR_VALUE      1            /* 0 = strobe ratio  3               */
                                         /* 1 = strobe ratio  7               */
                                         /* 2 = strobe ratio  15             */
                                         /* 3 = strobe ratio  31             */
/* Data rate                                                                 */
#define ROMEO_DR_VALUE      1            /* 0 = 1.0 - 1.4kbaud               */
                                         /* 1 = 2.0 - 2.7kbaud               */
                                         /* 2 = 4.0 - 5.3kbaud               */
                                         /* 3 = 8.6 - 10.6kbaud              */
/* Mixer gain                                                                */
#define ROMEO_MG_VALUE      0            /* 0 = Normal                       */
                                         /* 1 = -17dB (typical)              */
/* MS switch                                                                 */
#define ROMEO_MS_VALUE      0            /* 0 = to mixer output              */
                                         /* 1 = to IF input                  */

/* Phase comparator gain                                                     */
#define ROMEO_PG_VALUE      1            /* 0 = high gain mode               */
                                         /* 1 = low gain mode                */

/*****************************************************************************/
/*            These may be omitted depending on hardware setup               */
/*****************************************************************************/
#define ROMEO_STROBE    PTD_PTD1         /* #defines for STROBE pin          */
#define ROMEO_STROBE_DDR  DDRD_DDRD1     /* If hardwired,delete #defines     */

#define  ROMEO_AGC      PTB_PTB4           /* #defines for AGC pin             */
#define ROMEO_AGC_DDR    DDRB_DDRB4       /* If hardwired,delete #defines     */

#define ROMEO_AGC_VALUE     1            /* 1 -> slow, OOK                   */
                                         /* 0 -> fast, FSK                   */

/*These are required for use with Motorola's rf modules                      */
#define ROMEO_ENABLELNA    PTD_PTD2       /* #defines for LNA pin             */
#define ROMEO_ENABLELNA_DDR DDRD_DDRD2   /* If hardwired,delete #defines     */
/*****************************************************************************/
```

```
/*****************************************************************************/
/* This defines default values for  #defines in the Romeo.h , or prints      */
/* errors if missing or incorrect values have been chosen                    */
/*                        DO NOT EDIT THIS SECTION!!                          */

#ifndef ROMEO_SPI_ADDRESS
#error "You must #define symbol ROMEO_SPI_ADDRESS in Romeo.H header file"
#endif

#ifndef ROMEO_MAX_DATA_SIZE
#error "You must #define symbol ROMEO_MAX_DATA_SIZE in Romeo.H header file"
#endif

#ifndef ROMEO_RESET
#error "You must #define symbol ROMEO_RESET in Romeo.H header file"
#endif

#ifndef ROMEO_RESET_DDR
#error "You must #define symbol ROMEO_RESET_DDR in Romeo.H header file"
#endif

#ifndef ROMEO_MODE_VALUE
#error "You must #define symbol ROMEO_MODE_VALUE in Romeo.H header file"
#endif


#if ROMEO_MODE_VALUE ==ROMEO_OOK
        //If OK, do nuthin
#else
    #if ROMEO_MODE_VALUE ==ROMEO_FSK
        //If OK, do nuthin
    #else
        #error "You must set ROMEO_MODE_VALUE to ROMEO_OOK or \
              ROMEOO_FSK in Romeo.H header file"
    #endif
#endif


#ifndef ROMEO_BAND_VALUE
#error "You must #define symbol ROMEO_BAND_VALUE in Romeo.H header file"
#endif

#ifndef ROMEO_SOE_VALUE
#error "You must #define symbol ROMEO_SOE_VALUE in Romeo.H header file"
#endif

#ifndef ROMEO_HE_VALUE
#error "You must #define symbol ROMEO_HE_VALUE in Romeo.H header file"
#endif

#ifndef ROMEO_ID_VALUE
#error "You must #define symbol ROMEO_ID_VALUE in Romeo.H header file"
#endif

#ifndef ROMEO_SPI_CLOCK_SPEED
#error "You must #define symbol ROMEO_SPI_CLOCK_SPEED in Romeo.H header file"
#endif

#ifndef ROMEO_SR_VALUE
#error "You must #define symbol ROMEO_SR_VALUE in Romeo.H header file"
#endif

#ifndef ROMEO_DR_VALUE
```

```
#error "You must #define symbol ROMEO_DR_VALUE in Romeo.H header file"
#endif

#ifndef ROMEO_MG_VALUE
#error "You must #define symbol ROMEO_MG_VALUE in Romeo.H header file"
#endif

#ifndef ROMEO_MS_VALUE
#error "You must #define symbol ROMEO_MS_VALUE in Romeo.H header file"
#endif

/*****************************************************************************/
/* This section contains various values calculated from above data           */
/*                        DO NOT EDIT THIS SECTION!!                         */
/*                                                                           */
/* Timer register offsets                                                    */
/* Register address offsets for normal HC08 SPI                              */
#define ROMEO_SPCR  *(unsigned char *)(ROMEO_SPI_ADDRESS+0) /*SPI Control reg*/
#define ROMEO_SPSCR *(unsigned char *)(ROMEO_SPI_ADDRESS+1) /*SPI St/Ctrl reg*/
#define ROMEO_SPDR  *(unsigned char *)(ROMEO_SPI_ADDRESS+2) /*SPI Data reg   */



/*  CR1 byte                                                                 */
/* This macro constructs the CR1 byte using above definitions                */
#define ROMEO_CR1_VALUE   ROMEO_HE_VALUE+(ROMEO_DME_VALUE*2)+(ROMEO_SR_VALUE*4)\
        +(ROMEO_SOE_VALUE*16)+(ROMEO_MODE_VALUE*32)+(ROMEO_BAND_VALUE*64)


/* CR3 byte                                                                  */
/* This macro constructs the CR3 byte using above definitions                */

#define ROMEO_CR3_VALUE   (ROMEO_PG_VALUE*8)+(ROMEO_MS_VALUE*16)\
        +(ROMEO_MG_VALUE*32)+(ROMEO_DR_VALUE*64)



/* SPI baud rate divider                                                     */
/* Chooses appropriate baud rate divisor to provide max comms speed to Romeo */
#if (ROMEO_SPI_CLOCK_SPEED/307000) <= 2
    #define ROMEO_SPI_BAUD_RATE_DIVISOR  0

#elif (ROMEO_SPI_CLOCK_SPEED/307000) <= 8
    #define ROMEO_SPI_BAUD_RATE_DIVISOR  1

#elif (ROMEO_SPI_CLOCK_SPEED/307000) <= 32
    #define ROMEO_SPI_BAUD_RATE_DIVISOR  2

#elif (ROMEO_SPI_CLOCK_SPEED/307000) <= 128
    #define ROMEO_SPI_BAUD_RATE_DIVISOR  3
#endif


/* Enable/disable Data Manager                                            */
#define ROMEO_DME_VALUE     1               /* 0 = Data manager disabled  */
                                            /* 1 = Data manager enabled    */
/* DATA MANAGER ALWAYS USD IN THIS VERSION !!                             */


typedef union
{
  unsigned char Byte;
  struct
  {
        unsigned char overrunError  :1;/*Message buffer overrun, last
                                                           message lost !   */
        unsigned char checksumError :1;/* Last msg received had checksum
                                                           error            */
    unsigned char disabled      :1; /* Driver disabled                      */
    unsigned char res        :5; /* Unused                                   */
  }Bits;
}tROMEO_STATUS;



/** Driver Status **/
//#define ROMEO_READY        1 //Already defined above
#define ROMEO_DISABLED       2 /* Driver disabled                            */
#define ROMEO_OVERRUN        3 /* Data buffer overrun, last message lost     */
#define ROMEO_CHECKSUM_ERROR 4 /* Last message discarded with checksum error */
#define ROMEO_MSG_READY      5 /* Msg ready                                  */
#define ROMEO_NO_MSG         6 /* Driver enabled, no msgs waiting            */




/* Function Prototypes                                                       */
void RomeoInitialise(void);
unsigned char RomeoStatus(void);      //DEBUG version
void RomeoEnable(void);
void RomeoDisable(void);
void RomeoStrobeHigh(void);
void RomeoStrobeLow(void);
void RomeoStrobeTriState(void); /* Useful if you want to override rc strobe  */
interrupt void RomeoSPIRxInt(void);
void RomeoChangeConfig(unsigned char cr1, unsigned char cr2, unsigned char cr3);
                                  /*Useful if you want to change Romeo setup */
void RomeoCalcChecksum(unsigned char temp);

#endif /* ROMEO_H */
```

6.2.1.1.3 DRIVERSTRIAC.h

```
#include "driversMaster.h" /* Include peripheral declarations */

#define TIMER_LIMIT_TRIAC_ON  2  /* Limit of time base to retain the TRIAC
                                  *  output in one.
                                  */

/* Maximum time to activate the TRIAC (Minimum luminance level) at 7.6 ms at
 *  90% of half cycle of 60 Hz. This line can be used to calibrate the triac
 */
#define TIMER_LIMIT_100  ((unsigned long)(GTIME_BASE_INTERRUPT_PERMS * 8)+1)

/*
 * In the HLSW you put this code
 * In the definition of globals vars
 *       extern UINT8 u8timerTriac;
 * In the main()
 *       if (u8timerTriac < 1) TriacTimeBase();
 *  In the timer interrupt
 *       if (u8timerTriac>0) u8timerTriac--;
 */
```

```
/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/*
 * Comment the next line for disable the triac functionality
 */
#define TRIAC          PTB_PTB6           /* Data TRIAC 0 */
#define TRIAC_DD     DDRB_DDRB6           /* Data Direction TRIAC 0 */

/*
 * Register and bits used to configurate the interrupt for triac sync.
 */
#ifndef IRQ_EXISTS
   #define IRQ_EXISTS      0
   #define IRQ_SC_REG      KBSCR       /* IRQ Status and Control */
   #define IRQ_SCP_FLAG    3           /* Flag bit of IRQ_SC_REG */
   #define IRQ_SCP_ACK     2           /* Acknowledge bit of IRQ_SC_REG */
   #define IRQ_SCP_EN      1           /* Enable bit of IRQ_SC_REG */
   #define IRQ_SCP_MOD     0           /* Edge and/or Level detection */
   #define IRQ_EN          KBIER_KBIE0 /* Enable the interrupt in the
                                        *  specific pin
                                        */
   #define IRQ_SECOND      1           /* How many interrupts are detected
                                        *  in each cycle
                                        */
#endif

/******************************* DON´T MODIFY ********************************/

/* Functions Prototypes */
void TriacInit(void);
void TriacEnable(void);
void TriacDisable(void);
void TriacSync(void);
void TriacLevel(UINT8 u8Level);
void TriacTimeBase(void);
```

6.2.1.1.4 DRIVERSLCD.h

```
#include "driversMaster.h" /* Include peripheral declarations */

/*
 * In the HLSW you must put this piece of code
 *     In the definition of globals vars
 *         extern UINT8 u8TimerLCD;
 *     In the main()
 *         if (u8TimerLCD < 1) LCDTimeBase();
 *     In the timer interrupt
 *         if (u8TimerLCD > 0) u8TimerLCD--;
 */

/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/*
 * Comment the next line for disable LCD functionality
 */
#define LCD_EXISTS

#ifdef LCD_EXISTS
  #define LCD_E        PTA_PTA7     /* I/O pin used as Enable signal of LCD */
  #define LCD_E_DD     DDRA_DDRA7   /* DDR of LCD_E */
  #define LCD_RS       PTC_PTC7     /* I/O pin used as RS signal of LCD */
  #define LCD_RS_DD    DDRC_DDRC7   /* DDR of LCD_RS */
  #define LCD_DATA     PTA          /* Port with 4 I/O pins used to control
                                     *  LCD Data/Instructions signals
                                     */
  #define LCD_DATA_DD  DDRA         /* DDR of LCD_DATA */
  #define LCD_DATA_START 0          /* Number of pin in the port that start
                                     *  the 4 pins count used for LCD
                                     */
#endif

/******************************* DON´T MODIFY ********************************/

/* Driver Status */
#define LCD_STATUS_WAITING_INIT 0 /* LCD is waiting for initialization */
#define LCD_STATUS_READY    1     /* LCD is ready to use */
#define LCD_STATUS_ERROR    2     /* Error ocurred when you are using the LCD
                                   *  and you try to execute other operation.
                                   * You can change the state
                                   *  using LCDClear() function.
                                   */
#define LCD_STATUS_PRINTING 3     /* LCD is printing string */
#define LCD_STATUS_INIT     4     /* LCD is initializing */
#define LCD_STATUS_WAITING  5     /* LCD status are waiting for ready mode */

/* Functions Prototypes */
void LCDInit(void);               /* Initialize the LCD */
void LCDClear(void);              /* Clear the LCD */
void LCDCR(void);                 /* Go to second line of LCD */
void LCDPrint(UINT8 *u8Where, UINT8 u8Length); /* Print from [where] memory
                                                *  address [length]
                                                *  characters
                                                */
void LCDTimeBase(void);           /* Time Base of LCD */
UINT8 LCDStatus(void);            /* Return the status of the LCD */
void LCDCursor(UINT8 u8DdramAddress); /* Send the address which you can put
                                       *  the cursor
                                       */
```

6.2.1.1.5 DRIVERSLEDS.h

```
#include "driversMaster.h" /* Include peripheral declarations */

/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/*
 * Comment the lines for disables Leds functionality
 */
#define LED_ONE         PTB_PTB1          /* Data led 0 */
//#define LED_TWO       PTB_PTB5            /* Data led 1 */
//#define LED_THREE     PTAD_PTAD7          /* Data led 2 */
#define LED_FOUR        PTB_PTB5          /* Data led 3 */
//#define LED_FIVE        PTC_PTC2            /* Data led 4 */
//#define LED_SIX       PTC_PTC5            /* Data led 5 */
//#define LED_SEVEN      PTC_PTC4            /* Data led 6 */
//#define LED_EIGHT      PTDD_PTDD3          /* Data led 7 */

#ifdef LED_ONE
  #define LED_ONE_DD    DDRB_DDRB1           /* Data Direction led 0 */
#endif
#ifdef LED_TWO
  #define LED_TWO_DD    DDRB_DDRB5           /* Data Direction led 1 */
#endif
#ifdef LED_THREE
  #define LED_THREE_DD   DDRB_DDRB5           /* Data Direction led 2 */
#endif
#ifdef LED_FOUR
  #define LED_FOUR_DD   DDRB_DDRB5           /* Data Direction led 3 */
#endif
#ifdef LED_FIVE
  #define LED_FIVE_DD   DDRC_DDRC2           /* Data Direction led 4 */
#endif
#ifdef LED_SIX
  #define LED_SIX_DD    DDRC_DDRC5           /* Data Direction led 5 */
#endif
#ifdef LED_SEVEN
  #define LED_SEVEN_DD   DDRC_DDRC4           /* Data Direction led 6 */
#endif
#ifdef LED_EIGHT
  #define LED_EIGHT_DD   DDRC_DDRC4           /* Data Direction led 7 */
#endif

/******************************* DON´T MODIFY ********************************/

#define LED_ON    0   /* Value for led ON */
#define LED_OFF   1   /* Value for led OFF */

/* Led name relation */
#define LD_ONE    0   /* Led number 0 */
#define LD_TWO    1   /* Led number 1 */
#define LD_THREE   2   /* Led number 2 */
#define LD_FOUR   3   /* Led number 3 */
#define LD_FIVE   4   /* Led number 4 */
#define LD_SIX     5   /* Led number 5 */
#define LD_SEVEN  6   /* Led number 6 */
#define LD_EIGHT  7   /* Led number 7 */

/* Functions Prototypes */
void LedsInit(void);
void LedOn(UINT8 u8LedNumber);
void LedOff(UINT8 u8LedNumber);
void LedToggle(UINT8 u8LedNumber);
```

6.2.1.1.6 DRIVERSRELAY.h

```
#include "driversMaster.h" /* Include peripheral declarations */

/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/*
 * Comment the next line for disable relay functionality
 */
#define RELAY         PTD_PTD4        /* Data RELAY */
#ifdef RELAY
   #define RELAY_DD  DDRD_DDRD4      /* Data Direction RELAY */
#endif



/******************************* DON´T MODIFY ********************************/

#define RELAY_ON     1    /* Value for relay ON */
#define RELAY_OFF    0    /* Value for relay OFF */

/* Functions Prototypes */
void RelayInit(void);
void RelayOn(void);
void RelayOff(void);
void RelayToggle(void);
UINT8 RelayStatus(void);
```

6.2.1.1.7 DRIVERSSWITCH.h

```
#include "driversMaster.h" /* Include peripheral declarations */


/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/*
 * Comment the lines for disables the switch functionality
 */
#define SWITCH_ONE      PTB_PTB0              /* Data switch 0 */
//#define SWITCH_TWO      PTAD_PTAD1            /* Data switch 1 */
#ifdef SWITCH_ONE
//   #define SWITCH_ONE_PE  PTAPE_PTAPE0        /* Pullup Enable switch 0 */
   #define SWITCH_ONE_DD  DDRB_DDRB0          /* Data Direction switch 0 */
#endif
#ifdef SWITCH_TWO
   #define SWITCH_TWO_PE  PTAPE_PTAPE1        /* Pullup Enable switch 1 */
   #define SWITCH_TWO_DD  PTADD_PTADD1        /* Data Direction switch 1 */
#endif


/******************************* DON´T MODIFY ********************************/

/* Switch name relation */
#define SW_ONE      0
#define SW_TWO      1

/* Functions Prototypes */
void SwitchInit(void);
UINT8 SwitchStatus(UINT8 u8SwitchNumber);
```

6.2.1.1.8 DRIVERSMASTER.h

```
/* THIS SECTION CONTAINS VALUES YOU MUST DEFINE! */

/* Include peripheral declarations */
#ifndef MC68HC908AP64_h
  #define MC68HC908AP64_h
  #include <MC68HC908AP64.h>
#endif


/* Time Base */
#define GTIME_BASE_INTERRUPT_EACH_US    80


/* Kind of MCU */
#define MC908
//#define MCS08

/****************************** DON´T MODIFY *******************************/

/* Data Types */
typedef unsigned char    UINT8;
typedef unsigned short   UINT16;
typedef unsigned long    UINT32;

/* This section contains values calculated from above data */
#define GTIME_BASE_INTERRUPT_PERMS    (1000/GTIME_BASE_INTERRUPT_EACH_US)
```

6.2.1.2 Source Code Files

6.2.1.2.1 MAIN.c

```
/*****************************************************************************
*
*       Copyright (C) 2004 Freescale Semiconductor Mexico
*       All Rights Reserved
*
* Filename:     $RCSfile: main.c,v $
* Author:       $Author: a20701, a20702, r57191, a20705 $
* Locker:       $Locker: a20701, a20702, r57191, a20705 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:    Romeo2 with AP64, recieve msg with header
*
* History:
*
*
* Description: Probe in a the baseboard with AP64 and Romeo2
*              comunication with other component with Tango or Echo.
*
*
*
* Notes:
*
*
****************************************************************************/
#include <hidef.h>                       /* for EnableInterrupts macro       */
#include <MC68HC908AP64.h>              /* Include peripheral declarations   */
```

```
#include "Romeo.h"                      /* Include Romeo driver header file  */
#include "Teamac.h"                      /* Include Teamac driver header file */

#include "driversMaster.h"           /* Include general driver headers files */
#include "driversLeds.h"
#include "driversTriac.h"
#include "driversLcd.h"
#include "driversSwitch.h"
#include "driversRelay.h"

/* Timers */
extern UINT8 u8TimerLCD;
extern UINT8 u8TimerTriac;
UINT16 timerDimmer;

#define delay_ms(ms)        (GTIME_BASE_INTERRUPT_EACH_US*ms)

/* Globar variables */
UINT8 flagBasePrintLCD;                /* Flag to controlate the LCD print    */
UINT8 temp;                            /* Temporaly variable for conversions  */
UINT8 dimmerLevel;                    /* Instant level of dimmer             */
UINT8 dimmerLimit;                    /* Final status of dimmer              */
UINT8 dimmerFlag;                      /* Flag to indicate: 1 - Turnning On;
                                               2 - Turnning On; 0 - Nothing; */
UINT8 impPot[3];                      /* Array of decimal value of the dimmer*/
UINT8 wichMAC[4];                      /* Mac result of Teamac procces        */
UINT8 wichCNT;                        /* Count number of the transmition     */
UINT8 charPressed;                    /* Last character sended from tango    */

extern unsigned char romeoReceiveBuffer[];   /* Declare Romeo receive buffer */

/*Declarations for TEAMAC*/
unsigned long MACreceived;
unsigned long cipherText[2];
unsigned long key[4];
unsigned long TEAMAC_Data[2];
unsigned long TEAMAC_Code;
#pragma CONST_SEG MY_SEG
const unsigned char TEAMAC_Key[8]={0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08};
#pragma CONST_SEG DEFAULT


/* Flash rate to indicate the frequency to program */
#define LED2_FLASH_RATE  0x7fff


/* Flag to indicate the status of Romeo */
extern tROMEO_STATUS romeoStatus;

/*************************************************************************/

/* Declaration of functions */
/* Convert to decimal print from hexadecimal number */
/* Pre : Number in hexadecimal format and pointer to decimal array */
/* Post: Array of decimal values */
void Dec2Ascii(UINT8 Number, UINT8 *Destination);

/* Flash LED 1, duration */
/* Pre : LED2 pin configured as output */
/* Post: LED2 flashed once */
void FlashLED2(void)
{
    unsigned int i;
    LedOn(LED_ONE);
    for ( i=0;i < LED2_FLASH_RATE;i++) {}
    LedOff(LED_ONE);
    for ( i=0;i < LED2_FLASH_RATE;i++) {}
}


void main(void)
{

  /* Initialization of global variables */
  flagBasePrintLCD = 0;
  dimmerLevel = 0;
  dimmerFlag = 0;

  EnableInterrupts; /* enable interrupts */

  CONFIG1 = 17;                        /* Set the CONFIG1 register */
  /* PLL Initialization */

  /* CONFIG2: STOPICLKEN=1,STOPRCLKEN=0,STOPXCLKEN=0,OSCCLK1=0,
          OSCCLK0=0,??=0,??=0,SCIBDSRC=0 */
  CONFIG2 = 128;                       /* Set the CONFIG2 register */
  PCTL_BCS = 0;                        /* Select clock source from XTAL */
  PCTL_PLLON = 0;                      /* Disable the PLL */
  PMS = 900;                           /* Set the multiplier */
  PMRS = 192;                          /* Set the range select */
  PCTL = 0;
  PCTL_VPR = 2;
  PBWC = 128;                          /* Select the operating modes */
  PCTL_PLLON = 1;                      /* Enable the PLL */
  while(!PBWC_LOCK);                   /* Wait */
  PCTL_BCS = 1;                        /* Select clock source from PLL */
  __asm("nop");
  __asm("nop");


  /* Timer initialization */
  T1SC_TOIE = 1;                      /* Enable overflow interrupt */
  T1SC_PS0 = 0;                        /* Select prescale divisor */
  T1SC_PS1 = 1;
//  T1SC_PS1 = 0;                      /* For xtal = 9.8304 MHz */
  T1SC_PS2 = 0;        /* For Fbus = 7.3728 MHz; remember Fbus = xtal/4 */
//  T1MOD = 0x0171;    /* For stops of 200 us, this delay is the value
//                                   of a variable in driversGlobals.h */
  T1MOD = 0x0093;      /* For stops of 20 us, this delay is the value of
                                        a variable in driversGlobals.h */

  T1SC_TSTOP = 0;                      /* Normal operation */

  /* Initialization of drivers */
  LedsInit();
  TriacInit();
  SwitchInit();
  LCDInit();
  RelayInit();

  TriacEnable();

  FlashLED2();       // Two flashes tu indicate the frequency of 315 Mhz

  RomeoInitialise(); // Initialise Romeo driver with settings in Romeo.h file
```

```
RomeoChangeConfig((ROMEO_CR1_VALUE & 0xBf), ROMEO_ID_VALUE ,ROMEO_CR3_VALUE);
RomeoEnable();     // This enables Romeo to receive messages

for(;;) {


  if (u8TimerLCD == 0) LCDTimeBase();

  switch (RomeoStatus()) {

    case ROMEO_MSG_READY:

      TEAMAC_Data[0]=(unsigned long)romeoReceiveBuffer[1];
      TEAMAC_Data[1]=(unsigned long)romeoReceiveBuffer[2];
      char2Long(&MACreceived,&romeoReceiveBuffer[4]);

      char2Long(key, TEAMAC_Key);
      char2Long(key+1, TEAMAC_Key+1);
      char2Long(key+2, TEAMAC_Key+2);
      char2Long(key+3, TEAMAC_Key+4);

      encipher(TEAMAC_Data, cipherText, key);

      TEAMAC_Code = cipherText[0] ^ cipherText[1];

       if(MACreceived == TEAMAC_Code) {

        wichMAC[0] = romeoReceiveBuffer[4];
        wichMAC[1] = romeoReceiveBuffer[5];
        wichMAC[2] = romeoReceiveBuffer[6];
        wichMAC[3] = romeoReceiveBuffer[7];
        wichCNT = romeoReceiveBuffer[1];


        if(romeoReceiveBuffer[2]==0x02) {          // Value of triac

          Dec2Ascii(romeoReceiveBuffer[3],impPot);
          if ((dimmerFlag == 0)&&(RelayStatus() == RELAY_ON)) {
            dimmerLimit = romeoReceiveBuffer[3];
            dimmerLevel = dimmerLimit;
            Dec2Ascii(dimmerLevel,impPot);
            TriacLevel((UINT8)(dimmerLevel/3));
          }

        }
        else if (romeoReceiveBuffer[2]==0x01) {   // Open relay

          if (RelayStatus() != RELAY_ON) {
             dimmerLimit = romeoReceiveBuffer[3];
             dimmerLevel = (dimmerLimit == 0)?1:0;
             RelayOn();
            dimmerFlag = 1;
          }

         }
         else if (romeoReceiveBuffer[2]==0x00)  {   // Close relay

          if (RelayStatus() != RELAY_OFF) {
            dimmerLimit = 0;
            if (dimmerLevel == 0)  dimmerLevel = 1;
                                    // make the conditional below true
            dimmerFlag = 2;
          }
        }
        else if (romeoReceiveBuffer[2]==0x03)  {   // Character sended

         charPressed = romeoReceiveBuffer[3];

        }
      }


      romeoReceiveBuffer[0] = romeoReceiveBuffer[0] & 0x7f;
                                              // Clear buffer full flag
      break;

    case ROMEO_OVERRUN:

      romeoReceiveBuffer[0] = romeoReceiveBuffer[0] & 0x7f;
      break;

    case ROMEO_CHECKSUM_ERROR:

      romeoReceiveBuffer[0] = romeoReceiveBuffer[0] & 0x7f;
                                              // Clear buffer full flag
      break;

    case ROMEO_DISABLED:

      break;

    case ROMEO_NO_MSG:

      break;

    default:

      break;

  }

  {
    if((timerDimmer == 0)&&(dimmerLimit != dimmerLevel)&&(dimmerFlag != 0)){

      if (dimmerLimit > dimmerLevel) {
        if ((dimmerLimit - dimmerLevel)>=3) {
          dimmerLevel += 3;
        } else {
          dimmerLevel = dimmerLimit;
        }
      }
      else {
        if ((dimmerLevel - dimmerLimit)>=3) {
          dimmerLevel -= 3;
        } else {
          dimmerLevel = dimmerLimit;
        }
      }

      Dec2Ascii(dimmerLevel,impPot);
      TriacLevel((UINT8)(dimmerLevel/3));

      if (dimmerLimit != dimmerLevel) {
        timerDimmer = delay_ms(20);
      }
```

```
        else {
          if ((dimmerLimit == 0) && (dimmerFlag == 2)) {
            RelayOff();
          }
          dimmerFlag = 0;
        }

      }
    }

    if (LCDStatus() == LCD_STATUS_READY) {
      if (flagBasePrintLCD == 0) {  // MAC
        flagBasePrintLCD = 1;
        LCDCursor(0x08);
      }
      else if (flagBasePrintLCD == 1) {
        flagBasePrintLCD = 2;
        LCDPrint("MAC:",4);
      }
      else if (flagBasePrintLCD == 2) {  // ANALOG
        flagBasePrintLCD = 3;
        LCDCursor(0x40);
      }
      else if (flagBasePrintLCD == 3) {
        flagBasePrintLCD = 4;
        LCDPrint("ANALOG: ",8);
      }
      else if (flagBasePrintLCD == 4) {  // CNT
        flagBasePrintLCD = 5;
        LCDCursor(0x4A);
      }
      else if (flagBasePrintLCD == 5) {
        flagBasePrintLCD = 6;
        LCDPrint("CNT:",4);
      }
      else if (flagBasePrintLCD == 6) {  // Relay
        flagBasePrintLCD = 7;
        LCDCursor(0x00);
      }
      else if (flagBasePrintLCD == 7) {
        flagBasePrintLCD = 8;
        if (RelayStatus()==RELAY_ON) {
          LCDPrint("OPEN ",5);
        }
        else {
          LCDPrint("CLOSE",5);
        }
      }
      else if (flagBasePrintLCD == 8) {  // Triac
        flagBasePrintLCD = 9;
        LCDCursor(0x47);
      }
      else if (flagBasePrintLCD == 9) {
        flagBasePrintLCD = 10;
        LCDPrint(impPot,3);
      }
      else if (flagBasePrintLCD == 10) {  // MAC
        flagBasePrintLCD = 11;
        LCDCursor(0x0C);
      }
      else if (flagBasePrintLCD == 11) {
        flagBasePrintLCD = 12;
        LCDPrint(wichMAC,4);
      }
      else if (flagBasePrintLCD == 12) {  // Count
        flagBasePrintLCD = 13;
        LCDCursor(0x4E);
      }
      else if (flagBasePrintLCD == 13) {
        flagBasePrintLCD = 14;
        temp = (((wichCNT)>>4) & 0x0F) + '0';
        if (temp > '9') temp += 7;
        LCDPrint(&temp,1);
      }
      else if (flagBasePrintLCD == 14) {
        flagBasePrintLCD = 15;
        temp = ((wichCNT) & 0x0F) + '0';
        if (temp > '9') temp += 7;
        LCDPrint(&temp,1);
      }
      else if (flagBasePrintLCD == 15) {   // Character pressed
        flagBasePrintLCD = 16;
        LCDCursor(0x06);
      }
      else if (flagBasePrintLCD == 16) {
        flagBasePrintLCD = 0;
        LCDPrint(&charPressed,1);
      }
    }

  }
}

void interrupt 7 timeOverFlowInterrupt(void) {

    T1SC &= 0x7F;  // Reset the flag
    if (u8TimerLCD>0) u8TimerLCD--;
    if (u8TimerTriac>0) u8TimerTriac--;
    if (u8TimerTriac == 0) TriacTimeBase();
    if (timerDimmer > 0) timerDimmer--;

}

void interrupt 15 kbiInterrupt(void) {

    TriacSync();
    IRQ_SC_REG |= (0x01<<IRQ_SCP_ACK);  // Reset the flag

}

void Dec2Ascii(UINT8 Number, UINT8 *Destination) {

    UINT8 ThirdDigit = 0, SecondDigit = 0, FirstDigit = 0;

    ThirdDigit = (UINT8)(Number/100);
    Number = Number-(ThirdDigit*100);
    SecondDigit= (UINT8)(Number/10);
    Number = Number-(SecondDigit*10);
    FirstDigit = Number;

    *Destination = ThirdDigit  | 0x30;
    Destination++;
    *Destination = SecondDigit | 0x30;
    Destination++;
    *Destination = FirstDigit  | 0x30;
}
```

6.2.1.2.2 TEAMAC.c

```
#include "teamac.h"

extern unsigned long TEAMAC_Data[2];
extern unsigned long TEAMAC_Code;
extern unsigned char TEAMAC_Key[8];


void char2Long(unsigned long *pDest,const unsigned char *pSrce)
{
  unsigned char bytes = 4;
  *pDest = 0;
  while (bytes--)
    {
    *pDest <<= 8;
    *pDest |= (*pSrce & 0xFF);
    *pSrce++;
    }
}


void Long2char(unsigned char *pDest,unsigned long *pSrce)
{
  unsigned char i;
  pDest+=3;
  for(i=0;i<4;i++)
  {
    *pDest = (unsigned char)(((*pSrce)>>(8*i)) & 0x000000FF);
    pDest--;

  }

}

void encipher(unsigned long *v, unsigned long *w,unsigned long *k)
{
  unsigned long y, z, sum, delta;
  unsigned char n;

  y=*v;
  z=*(v+1);
  sum=0;
  n=32;
  delta=0x9E3779B9;


  while(n-- > 0)
    {
    y += (((z << 4) ^ (z >> 5)) + z) ^ (sum + k[sum&3]);
    sum += delta;
    z += (((y << 4) ^ (y >> 5)) + y) ^ (sum + k[(sum>>11) & 3]);
    }
  w[0]=y; w[1]=z;
}
```

6.2.1.2.3 START08.c

```
/*******************************************************************************
  FILE        : start08.c
  PURPOSE     : 68HC08 standard startup code
  LANGUAGE    : ANSI-C / INLINE ASSEMBLER
  ----------------------------------------------------------------------------
  HISTORY
    22 oct 93         Created.
    04/17/97          Also C++ constructors called in Init().
 ******************************************************************************/
#include <start08.h>

/**********************************************************************/
#pragma DATA_SEG FAR _STARTUP
struct _tagStartup _startupData;    /* read-only:
                                     _startupData is allocated in ROM and
                                     initialized by the linker */


#define USE_C_IMPL 0 /* for now, we are using the inline assembler implementation for the
startup code */

#if !USE_C_IMPL
#pragma MESSAGE DISABLE C20001 /* Warning C20001: Different value of stackpointer depending on
control-flow */
/* the function _COPY_L releases some bytes from the stack internally */

#ifdef __OPTIMIZE_FOR_SIZE__
#pragma NO_ENTRY
#pragma NO_EXIT
#pragma NO_FRAME
/*lint -esym(528, loadByte) inhibit warning about not referenced loadByte function */
static void near loadByte(void) {
  asm {
             PSHH
             PSHX
#ifdef __HCS08__
             LDHX    5,SP
             LDA     0,X
             AIX     #1
             STHX    5,SP
#else
             LDA     5,SP
             PSHA
             LDX     7,SP
             PULH
             LDA     0,X
             AIX     #1
             STX     6,SP
             PSHH
             PULX
             STX     5,SP
#endif
             PULX
             PULH
             RTS
  }
}
#endif /* __OPTIMIZE_FOR_SIZE__ */

#endif
```

```
/*lint -esym(752,_COPY_L)  inhibit message on dunction declared, but not used (it is used in
HLI) */
extern void _COPY_L(void);
/* DESC:    copy very large structures (>= 256 bytes) in 16 bit address space (stack incl.)
   IN:      TOS count, TOS(2) @dest, H:X @src
   OUT:
   WRITTEN: X,H */
#ifdef __ELF_OBJECT_FILE_FORMAT__
  #define toCopyDownBegOffs 0
#else
  #define toCopyDownBegOffs 2 /* for the hiware format, the toCopyDownBeg field is a long.
Because the HC08 is big endian, we have to use an offset of 2 */
#endif
static void Init(void) {
/* purpose:     1) zero out RAM-areas where data is allocated
                2) init run-time data
                3) copy initialization data from ROM to RAM
 */
  /*lint -esym(529,p,i)  inhibit warning about symbols not used: it is used in HLI below */
  int i;
  int *far p;
  /*lint +e529 */
#if USE_C_IMPL   /* C implementation of ZERO OUT and COPY Down */
  int j;
  char *dst;
  _Range *far r;

  r = _startupData.pZeroOut;

  /* zero out */
  for (i=0; i != _startupData.nofZeroOuts; i++) {
    dst = r->beg;
    j = r->size;
    do {
      *dst = 0; /* zero out */
      dst++;
      j--;
    } while(j != 0);
    r++;
  }
#else /* faster and smaller asm implementation for ZERO OUT */
  asm {
ZeroOut:     ;
             LDA    _startupData.nofZeroOuts:1 ; nofZeroOuts
             INCA
             STA    i:1                        ; i is counter for number of zero outs
             LDA    _startupData.nofZeroOuts:0 ; nofZeroOuts
             INCA
             STA    i:0
             LDHX   _startupData.pZeroOut      ; *pZeroOut
             BRA    Zero_5
Zero_3:    ;
            ; CLR    i:1 is already 0
Zero_4:    ;
             ; { HX == _pZeroOut }
             PSHX
             PSHH
             ; { nof bytes in (int)2,X }
             ; { address in (int)0,X   }
             LDA    0,X
             PSHA
             LDA    2,X
             INCA
             STA    p                  ; p:0 is used for high byte of byte counter
             LDA    3,X
             LDX    1,X
             PULH
             INCA
             BRA    Zero_0
Zero_1:     ;
            ;  CLRA   A is already 0, so we do not have to clear it
Zero_2:     ;
             CLR    0,X
             AIX    #1
Zero_0:     ;
             DBNZA  Zero_2
Zero_6:
             DBNZ   p, Zero_1
             PULH
             PULX                           ; restore *pZeroOut
             AIX    #4                      ; advance *pZeroOut
Zero_5:     ;
             DBNZ   i:1, Zero_4
             DBNZ   i:0, Zero_3
             ;
CopyDown:    ;

  }

#endif

  /* copy down */
  /* _startupData.toCopyDownBeg  --->  {nof(16) dstAddr(16) {bytes(8)}^nof} Zero(16) */
#if USE_C_IMPL /* (optimized) C implementation of COPY DOWN */
  p = (int*far)_startupData.toCopyDownBeg;
  for (;;) {
    i = *p; /* nof */
    if (i == 0) {
      break;
    }
    dst = (char*far)p[1]; /* dstAddr */
    p+=2;
    do {
      /* p points now into 'bytes' */
      *dst = *((char*far)p); /* copy byte-wise */
      ((char*far)p)++;
      dst++;
      i--;
    } while (i!= 0);
  }
#elif defined(__OPTIMIZE_FOR_SIZE__)
  asm {
#ifdef __HCS08__
             LDHX   _startupData.toCopyDownBeg:toCopyDownBegOffs
             PSHX
             PSHH
#else
             LDA    _startupData.toCopyDownBeg:(1+toCopyDownBegOffs)
             PSHA
             LDA    _startupData.toCopyDownBeg:(0+toCopyDownBegOffs)
             PSHA
#endif
Loop0:
             JSR    loadByte  ; load high byte counter
             TAX              ; save for compare
             INCA
             STA    i
             JSR    loadByte  ; load low byte counter
             INCA
             STA    i:1
             DECA
             BNE    notfinished
             CBEQX  #0, finished
notfinished:

             JSR    loadByte  ; load high byte ptr
             PSHA
             PULH
             JSR    loadByte  ; load low byte ptr
             TAX              ; HX is now destination pointer
             BRA    Loop1
Loop3:
Loop2:
             JSR    loadByte  ; load data byte
             STA    0,X
             AIX    #1
Loop1:
             DBNZ   i:1, Loop2
             DBNZ   i:0, Loop3
             BRA    Loop0

finished:
             AIS #2
    };
#else /* optimized asm version. Some bytes (ca 3) larger than C version (when considering the
runtime routine too), but about 4 times faster */
  asm {
#ifdef __HCS08__
             LDHX   _startupData.toCopyDownBeg:toCopyDownBegOffs
#else
             LDX    _startupData.toCopyDownBeg:(0+toCopyDownBegOffs)
             PSHX
             PULH
             LDX    _startupData.toCopyDownBeg:(1+toCopyDownBegOffs)
#endif
next:
             LDA   0,X    ; list is terminated by 2 zero bytes
             ORA   1,X
             BEQ copydone
             PSHX         ; store current position
             PSHH
             LDA   3,X    ; psh dest low
             PSHA
             LDA   2,X    ; psh dest high
             PSHA
             LDA   1,X    ; psh cnt low
             PSHA
             LDA   0,X    ; psh cnt high
             PSHA
             AIX   #4
             JSR  _COPY_L ; copy one block
             PULH
             PULX
             TXA
             ADD   1,X    ; add low
             PSHA
             PSHH
             PULA
             ADC   0,X    ; add high
             PSHA
             PULH
             PULX
             AIX   #4
             BRA next
copydone:
  };
#endif


  /* FuncInits: for C++, this are the global constructors */
#ifdef __cplusplus
#ifdef __ELF_OBJECT_FILE_FORMAT__
  i = (int)(_startupData.nofInitBodies - 1);
  while ( i >= 0) {
    (&_startupData.initBodies->initFunc)[i]();  /* call C++ constructors */
    i--;
  }
#else
  if (_startupData.mInits != NULL) {
    _PFunc *fktPtr;
    fktPtr = _startupData.mInits;
    while(*fktPtr != NULL) {
      (**fktPtr)(); /* call constructor */
      fktPtr++;
    }
  }
#endif
#endif
  /* LibInits: used only for ROM libraries */
}

#pragma NO_EXIT
#ifdef __cplusplus
  extern "C"
#endif
void _Startup (void) { /* To set in the linker parameter file: 'VECTOR 0 _Startup' */
/*  purpose:    1)  initialize the stack
                2)  initialize run-time, ...
                    initialize the RAM, copy down init dat etc (Init)
                3)  call main;
    called from: _PRESTART-code generated by the Linker
*/
#ifdef __ELF_OBJECT_FILE_FORMAT__
  DisableInterrupts;  /* in HIWARE format, this is done in the prestart code */
#endif
  for (;;) { /* forever: initialize the program; call the root-procedure */
    if (!(_startupData.flags&STARTUP_FLAGS_NOT_INIT_SP)) {
      /* initialize the stack pointer */
      INIT_SP_FROM_STARTUP_DESC();
    }
    Init();
    (*_startupData.main)();
  } /* end loop forever */
}
```

6.2.1.2.4 ROMEO.c

```
/******************************************************************************
*
*       Copyright (C) 2004 Motorola, Inc.
*       All Rights Reserved
*
* Filename:     $RCSfile: romeo.c,v $
* Author:       $Author: r29541 $
* Locker:       $Locker: r29541 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:    Romeo2 software driver for HC08
*
* History:
*
*
* Description:   This is C code for Romeo2 software driver for HC08
*
*
*
* Notes:
*
******************************************************************************/

#include <MC68HC908AP64.h>              /* include peripheral declarations   */
#include "Romeo.h"                      /* Include driver header file         */

/** Driver Internal States **/
#define ROMEO_READY    1    /* Ready to receive new message                    */
#define ROMEO_GOT_ID  2    /* Have received 1 or more valid ID bytes          */
                /* at start of message (no header byte )                     */
#define ROMEO_GET_DATA  3    /* Reading in bytes of data                   */
#define ROMEO_LAST_BYTE 4  /* Last byte is extra byte added by Romeo - ignore */


unsigned char romeoChecksum;

unsigned char romeoDataLength;   /* Length                                    */

unsigned char romeoDriverState;

unsigned char * romeoDataPtr;  /* pointer used to store data into message buffer */

unsigned char romeoInputBuffer[ROMEO_MAX_DATA_SIZE+2];/*Input buffer for incoming msg */
unsigned char romeoReceiveBuffer[ROMEO_MAX_DATA_SIZE+1];/*Data buffer for complete msg */



tROMEO_STATUS romeoStatus;

#define ROMEO_BUFFER_FULL 0x80              /* Mask for rx buffer full flag  */
                                            /* Buffer has format :-
                                                length + full flag byte
                                                data[0]
                                                ...
                                                ...
                                                data[7]
                                                                             */
unsigned char cr1, cr2, cr3;
```

```
/* Sets up the Romeo device. Note, Romeo remains in Sleep mode */
void RomeoInitialise(void)
{
  volatile unsigned char temp;
  romeoStatus.Byte = 0;                        /* Reset status                */
  ROMEO_SPCR  = 0x00;                      /* Disable SPI (and SPI interrupts) */
  ROMEO_RESET = 1;
  ROMEO_RESET_DDR  = 1;                   /* Put Romeo in master mode          */
  ROMEO_RESET      = 0;                   /* Then slave mode                   */
  ROMEO_SPSCR = ROMEO_SPI_BAUD_RATE_DIVISOR;

    ROMEO_SPCR = ROMEO_SPCR |0x20;       /* Set mcu to master, Romeo to slave */
  ROMEO_SPCR = 0x2a;                     /* Enable SPI                        */

  temp = ROMEO_SPSCR;
  temp = ROMEO_SPDR;                    /* Read data reg to clear receive flag) */
  ROMEO_SPDR = ROMEO_CR1_VALUE;          /* Send first control byte              */

  while( (ROMEO_SPSCR & 0x80) == 0 ) {}/* SPSCR_SPRF == 0 Wait until byte gone */
  temp = ROMEO_SPDR;                    /* Read data reg to clear receive flag) */
  ROMEO_SPDR = ROMEO_ID_VALUE;          /* Send second control byte             */

  while( (ROMEO_SPSCR & 0x80) == 0 ) {}/* SPSCR_SPRF == 0 Wait until byte gone */
  temp = ROMEO_SPDR;                    /* Read data reg to clear receive flag) */
  ROMEO_SPDR = ROMEO_CR3_VALUE;          /* Send third control byte              */

  while( (ROMEO_SPSCR & 0x80) == 0 ) {}/* SPSCR_SPRF == 0 Wait until byte gone */
  temp = ROMEO_SPDR;                    /* Read data reg to clear receive flag) */
  romeoDataPtr = &romeoInputBuffer[0]; /* Point to data buffer                 */
    romeoStatus.Bits.disabled = 1;     /* Driver disabled                      */
}



/* Return status of Romeo driver  */
unsigned char RomeoStatus(void)
{
    unsigned char result;
    asm sei;
  if (romeoStatus.Bits.disabled == 1)
      result = ROMEO_DISABLED;
  else if ( (romeoStatus.Bits.overrunError == 1)
          && ( (romeoReceiveBuffer[0] & ROMEO_BUFFER_FULL) == ROMEO_BUFFER_FULL) )
      result = ROMEO_OVERRUN;
  else if ( (romeoStatus.Bits.checksumError == 1)
          && ( (romeoReceiveBuffer[0] & ROMEO_BUFFER_FULL) == ROMEO_BUFFER_FULL) )
      result = ROMEO_CHECKSUM_ERROR;
  else if (  (romeoReceiveBuffer[0] & ROMEO_BUFFER_FULL) != 0 )
      result = ROMEO_MSG_READY;
  else
      result = ROMEO_NO_MSG;
    asm cli;
    return result;

}




/* Enable Romeo to send data on SPI */
void RomeoEnable(void)
{
    ROMEO_SPCR = ROMEO_SPCR & 0xdd; /* clear spe and spmstr                 */
  ROMEO_RESET = 1;                  /* Romeo now master on SPI               */
  ROMEO_SPCR = ROMEO_SPCR | 0x02;   /* SPCR_SPE = 1                          */
  ROMEO_SPSCR = ROMEO_SPSCR | 0x40; /* SPSCR_ERRIE = 1                       */
  ROMEO_SPCR = ROMEO_SPCR | 0x80;   /* SPCR_SPRIE = 1 enable SPI receive ints*/
  romeoDataPtr = &romeoInputBuffer[0];/* Point to data buffer             */

#ifdef ROMEO_STROBE                 /* Enable strobe, AGC and LNA if present */
    ROMEO_STROBE = 1;
    ROMEO_STROBE_DDR = 1;
#endif

#ifdef ROMEO_AGC
   ROMEO_AGC = ROMEO_AGC_VALUE;
   ROMEO_AGC_DDR = 1;
#endif

#ifdef ROMEO_ENABLELNA
    ROMEO_ENABLELNA = 1;
    ROMEO_ENABLELNA_DDR = 1;
#endif

  romeoDriverState = ROMEO_READY;
    romeoStatus.Byte = 0;            /* Clear error and disable flags        */
    asm cli;                         /* Enable interrupts                    */
}


/* Disable Romeo from sending data on SPI */
void RomeoDisable(void)
{
  ROMEO_SPCR = ROMEO_SPCR & 0xfd;  /* SPCR_SPE = 0   disable spi              */
  ROMEO_SPCR = ROMEO_SPCR | 0x20;  /* SPCR_SPMSTR = 1, mcu=master,Romeo=slave */
  ROMEO_SPCR = ROMEO_SPCR & 0x7f;  /* SPCR_SPRIE = 0 SPI receive ints disabled*/
  ROMEO_SPCR = ROMEO_SPCR | 0x02;  /* SPCR_SPE = 1 enable module              */

#ifdef ROMEO_STROBE                /* Disable strobe, AGC and LNA if present  */
    ROMEO_STROBE = 0;
#endif

#ifdef ROMEO_AGC
   ROMEO_AGC = 0;
#endif

#ifdef ROMEO_ENABLELNA
    ROMEO_ENABLELNA = 0;
#endif

    romeoStatus.Bits.disabled = 1;/* Set disabled bit, other bit values still */
}                                 /* valid for last message                   */



/* Turn on strobe pin */
void RomeoStrobeHigh(void)
{
#ifdef ROMEO_STROBE
    ROMEO_STROBE = 1;
    ROMEO_STROBE_DDR = 1;
#endif
}


/* Turn off strobe pin */
```

```
void RomeoStrobeLow(void)
{
#ifdef ROMEO_STROBE
    ROMEO_STROBE = 0;
    ROMEO_STROBE_DDR = 1;
#endif
}


/* Tristate strobe pin */
void RomeoStrobeTriState(void)
{
#ifdef ROMEO_STROBE
    ROMEO_STROBE_DDR = 0;
#endif
}


interrupt void RomeoSPIRxInt(void)
{

volatile unsigned char temp;
unsigned char i;

 temp = ROMEO_SPSCR;                  /* Read control reg with sprf flag set */
 temp = ROMEO_SPDR;                    /* Read data from SPI                  */
 if (romeoDriverState == ROMEO_READY)
 {
   romeoChecksum = ROMEO_ID_VALUE;     /* Start checksum calculation          */
   if ( ROMEO_HE_VALUE )                /* if header enabled                   */
   {
        RomeoCalcChecksum(temp);
      romeoDataPtr = &romeoInputBuffer[0]; /* Point to start of data buf for
                                                      next msg               */
    romeoDataLength  = temp +1;       /* make copy of length (+1 for checksum)*/
        if  (temp > ROMEO_MAX_DATA_SIZE) /* if length is too big or zero     */
        {
         romeoReceiveBuffer[0] = romeoInputBuffer[0] | ROMEO_BUFFER_FULL;
           romeoStatus.Bits.checksumError = 1; /* Checksum error !!!         */
           romeoDriverState = ROMEO_READY;     /* Wait for next message      */
           ROMEO_RESET = 0;
           ROMEO_RESET = 1;
        }
        else
    {
      *romeoDataPtr++ = temp ;       /* store length in buffer               */
       romeoDriverState = ROMEO_GET_DATA;
        }
  }
  else                            /* else header not enabled                 */
  {
     if ( temp == ROMEO_ID_VALUE )      /* if received byte == ID              */
     {
       romeoDriverState = ROMEO_GOT_ID;
     }
    else                      /* else if not = ID, ignore                    */
    {
    }

  }

  }
  else if (romeoDriverState == ROMEO_GOT_ID)  /* else if GOT_ID              */
  {
      if (temp == ROMEO_ID_VALUE)            /* if byte = ID, then ignore     */
                                              /* (its a repeat ID)           */
      {
      }
    else                      /* else its the length byte             */
    {
            RomeoCalcChecksum(temp);
          romeoDataPtr = &romeoInputBuffer[0];/*Point to start of data buf
                                                                 for next msg*/
       romeoDataLength  = temp+1;        /*make copy of length  (+1 for checksum)*/
            if (temp > ROMEO_MAX_DATA_SIZE)  // if length is too big
            {
              romeoReceiveBuffer[0] = romeoInputBuffer[0] | ROMEO_BUFFER_FULL;
                romeoStatus.Bits.checksumError = 1;  /* Checksum error !!!   */
                romeoDriverState = ROMEO_READY;      /* Wait for next message*/
                ROMEO_RESET = 0;
                ROMEO_RESET = 1;
            }
            else
      {   *romeoDataPtr++ = temp ;          /* store length in buffer        */
          romeoDriverState = ROMEO_GET_DATA;
        }
    }
  }
  else if (romeoDriverState == ROMEO_GET_DATA)
  {
    RomeoCalcChecksum(temp);
    *romeoDataPtr++ = temp;             /* store data in buffer               */
    romeoDataLength--;
    if (romeoDataLength == 0)
    {
      romeoDriverState = ROMEO_LAST_BYTE;
    }
  }
  else if (romeoDriverState == ROMEO_LAST_BYTE)   /* If last byte, ignore     */
  {                         /* This byte caused by extra bit sent  */
                                                 /* by Tango                 */


       if ( (romeoReceiveBuffer[0] & ROMEO_BUFFER_FULL) != 0)/*if buffer 1 full*/
       {
          romeoStatus.Bits.overrunError = 1;  /* overrun error, discard msg  */
         }
         else                                 /* Else copy msg to buffer 1   */
         {
              romeoStatus.Bits.overrunError = 0;/*previous overrun error cleared*/
              romeoReceiveBuffer[0] = romeoInputBuffer[0] | ROMEO_BUFFER_FULL;
           for (i = 1; i <= ROMEO_MAX_DATA_SIZE; i++)
/* Add buffer full flag */
                    romeoReceiveBuffer[i] = romeoInputBuffer[i];
       }
         if (romeoChecksum != 0xff)          /* If checksum not OK */
       {
             romeoStatus.Bits.checksumError = 1; /* Checksum error !!!   */
       }
         else
         {
            romeoStatus.Bits.checksumError = 0;
                                       /* Clear any previous checksum errors */
         }
         romeoDriverState = ROMEO_READY;
  }
```

```
}



/* Set values in Romeo registers */
/* Must have called ROmeoDisable before this function */

void RomeoChangeConfig(unsigned char cr1, unsigned char cr2, unsigned char cr3)
{
volatile unsigned char temp;

  ROMEO_SPCR  = 0x00;                     /* Disable SPI (and SPI interrupts) */
  ROMEO_RESET = 1;
  ROMEO_RESET_DDR  = 1;                   /* Put Romeo in master mode         */
  ROMEO_RESET      = 0;                   /* Then slave mode                   */
    ROMEO_SPCR = ROMEO_SPCR |0x20;       /* Set mcu to master,Romeo to slave */
  ROMEO_SPCR = 0x2a;                     /* Enable SPI                       */
  temp = ROMEO_SPSCR;
  temp = ROMEO_SPDR;                 /* Read data reg to clear receive flag) */
  ROMEO_SPDR = cr1;                   /* Send first control byte              */

  while( (ROMEO_SPSCR & 0x80) == 0 ) {}  /*SPSCR_SPRF == 0 Wait until byte gone*/
  temp = ROMEO_SPDR;                    /*Read data reg to clear receive flag)*/
  ROMEO_SPDR = cr2;                      /* Send second control byte          */

  while( (ROMEO_SPSCR & 0x80) == 0 ) {}  /*SPSCR_SPRF == 0 Wait until byte gone*/
  temp = ROMEO_SPDR;                    /*Read data reg to clear receive flag)*/
  ROMEO_SPDR = cr3;                      /* Send third control byte           */

  while( (ROMEO_SPSCR & 0x80) == 0 ) {}  /*SPSCR_SPRF == 0 Wait until byte gone*/
  temp = ROMEO_SPDR;                    /*Read data reg to clear receive flag)*/
}


/* helper function to calculate checksum */
/* Written in assembler, but can use commented out C if required */
void RomeoCalcChecksum(unsigned char temp)
{
//    romeoChecksum = romeoChecksum + temp;
//    if (romeoChecksum < temp)               /* if carry */
//        romeoChecksum++;
        asm
        {

            LDA romeoChecksum
            ADD temp
            ADC #$00
            STA romeoChecksum

        }

}
```

6.2.1.2.5 DRIVERSTRIAC.c

```
#include "driversTriac.h"

#define C_ACTIVE     1
#define C_INACTIVE   0

UINT8 u8TriacStatus;     /* Determine the internal status of the triac */
UINT8 u8TriacActivedPin; /* Used to determinate if the triac pin was
                           *  activated
                           */
UINT8 u8TriacSecond;     /* Used because the interrupt detect only
                           *  the falling edge
                           */
UINT8 u8TriacLevel;      /* Used to determine the actual level */

UINT8 u8TimerTriac;

/* Triac Driver */
#ifdef TRIAC

  /* Initialize TRIAC */
  void TriacInit(void) {

    /* Set pins to output */
    TRIAC_DD =     1;
    /* Set data to 1 (turn off) */
    TRIAC =       1;
    u8TriacStatus = C_INACTIVE;

    #ifdef IRQ_EXISTS
        IRQ_SC_REG &= ~(0x01<<IRQ_SCP_MOD);
        #ifdef MC908  // 908
          IRQ_SC_REG &= ~(0x01<<IRQ_SCP_EN);
        #else   // s08
          IRQ_SC_REG |= (0x01<<IRQ_SCP_EN);
        #endif
        IRQ_EN = 1;    /* Enabled the interrupt */
    #endif

  }

  /* Enable TRIAC */
  void TriacEnable(void) {

    u8TriacStatus = C_ACTIVE;
    TRIAC = 1;
    u8TriacActivedPin = 0;
    u8TriacSecond = 0;

  }

  /* Disable TRIAC */
  void TriacDisable(void) {

    u8TriacStatus = C_INACTIVE;
    u8TriacActivedPin = 0;
    TRIAC = 1;
    u8TriacSecond = 0;

  }
  /* Syncronize TRIAC */
  void TriacSync(void) {

    u8TimerTriac = TIMER_LIMIT_100 - u8TriacLevel;
    u8TriacActivedPin = 0;
    TRIAC = 1;
    u8TriacSecond = 0;

  }

  /* Set the Level of TRIAC */
  void TriacLevel(UINT8 u8Level) {

    if (u8Level < (TIMER_LIMIT_100-5)) {
      u8TriacLevel = u8Level;
    }
    else {
      u8TriacLevel = TIMER_LIMIT_100-5;
    }

  }

  /* Time Base */
  void TriacTimeBase(void) {

    if (u8TriacStatus == C_ACTIVE) {
      if ((u8TimerTriac < 1) && (!TRIAC) && (u8TriacActivedPin)) {
        TRIAC = 1;
        #ifdef IRQ_SECOND
 u8TimerTriac = ((7.8*GTIME_BASE_INTERRUPT_PERMS)-TIMER_LIMIT_TRIAC_ON);
/* calibrated
 */
//          u8TimerTriac = (9*GTIME_BASE_INTERRUPT_PERMS); /*calibrated*/
        #endif
      }
      else if (u8TriacActivedPin == 0) {
        if (u8TimerTriac < 1) {
          TRIAC = 0;
          u8TimerTriac = TIMER_LIMIT_TRIAC_ON;
          u8TriacActivedPin = 1;
        }
        else {  /* ignore */
        }
      }
      #ifdef IRQ_SECOND
      else if ((TRIAC) && (u8TriacActivedPin) && (!u8TriacSecond)) {
        u8TriacActivedPin = 0;
        TRIAC = 1;
        u8TriacSecond = 1;
      }
      #endif
    }
    else {    /* ingnore */
    }

  }

#endif
/******** END ** TRIAC Drivers **/
```

6.2.1.2.6 DRIVERSLCD.c

```
#include "driversLcd.h"

#define OUTNUMBER(Character)    ((Character&0x0F)<<LCD_DATA_START)
#define PORTMASK                (~(0x0F<<LCD_DATA_START))

#define C_ACTIVE     1
#define C_INACTIVE   0

UINT8 u8LCDInternalStatus = 0;  /* Flag for driver status */

UINT8 u8TimerLCD;               /* Counter for delays */

UINT8 u8HowMany;                /* Number of characters pending for print */
UINT8 *u8NextChr;                /* Pointer to next character to print */

UINT8 u8Columns;

/* Internal function for print a character */
void LCDPrintNext(void);

/* LCD Driver */
#ifdef LCD_EXISTS

    /* Indicate to LCD: read data */
    void LCDSend(void) {
        LCD_E = 1;
        LCD_E = 0;
    }

    /* LCD Initialization */
    void LCDInit(void) {

        static UINT8 u8LCDStatusInit;

        if (u8LCDInternalStatus == LCD_STATUS_WAITING_INIT) {

            /* Configure Pins to output */
            LCD_E_DD =    1;
            LCD_E =      0;
            LCD_RS_DD =   1;
            LCD_RS =     0;
            LCD_DATA_DD |=  (0x0F << LCD_DATA_START);
            LCD_DATA &=    PORTMASK;
            LCD_DATA |=    OUTNUMBER(0x00);

            u8LCDInternalStatus = LCD_STATUS_INIT;
            u8LCDStatusInit = 1;
            u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS * 15; /* Delay of 15ms */
        }
        else switch (u8LCDStatusInit) {
            case 1:
                LCD_DATA &= PORTMASK;
                LCD_DATA |= OUTNUMBER(0x03);
                LCDSend();
                u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS * 5;
                u8LCDStatusInit = 2;
                break;
            case 2:
                LCD_DATA &= PORTMASK;
                LCD_DATA |= OUTNUMBER(0x03);
```

```
         LCDSend();
         u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
         u8LCDStatusInit = 3;
         break;
     case 3:
         LCD_DATA &= PORTMASK;
         LCD_DATA |= OUTNUMBER(0x03);
         LCDSend();
         u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
         u8LCDStatusInit = 4;
         break;
     case 4:
         LCD_DATA &= PORTMASK;
         LCD_DATA |= OUTNUMBER(0x02); /* Format 4 bits */
         LCDSend();
         u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
         u8LCDStatusInit = 5;
         break;
     case 5:
         LCD_DATA &= PORTMASK;
         LCD_DATA |= OUTNUMBER(0x02);
         LCDSend();
         LCD_DATA &= PORTMASK;
         LCD_DATA |= OUTNUMBER(0x08); /* Display 5x10
                                      * 2 lines
                                      */
         LCDSend();
         u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
         u8LCDStatusInit = 6;
         break;
      case 6:
         LCD_DATA &= PORTMASK;
         LCD_DATA |= OUTNUMBER(0x00);
    LCDSend();
    LCD_DATA &= PORTMASK;
    LCD_DATA |= OUTNUMBER(0x0C); /* Display on
                                  * Cursor off
                                  * Blinking off
                                  */
    LCDSend();
    u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
    u8LCDStatusInit = 7;
    break;
case 7:
    LCD_DATA &= PORTMASK;
    LCD_DATA |= OUTNUMBER(0x00);
    LCDSend();
    LCD_DATA &= PORTMASK;
    LCD_DATA |= OUTNUMBER(0x06); /* Set mode */
    LCDSend();
    u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
    u8LCDStatusInit = 8;
    break;
case 8:
    LCD_DATA &= PORTMASK;
    LCD_DATA |= OUTNUMBER(0x00);
    LCDSend();
    LCD_DATA &= PORTMASK;
    LCD_DATA |= OUTNUMBER(0x01); /* Set mode */
    LCDSend();
    u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
    u8LCDStatusInit = 9;
    break;
```

```
      case 9:
          u8LCDInternalStatus = LCD_STATUS_READY;
          u8LCDStatusInit = 0;
          break;

       }
   }

   void LCDClear(void) {

       LCD_DATA &= PORTMASK;
       LCD_DATA |= OUTNUMBER(0x00);
       LCD_RS = 0;
       LCDSend();
       LCD_DATA &= PORTMASK;
       LCD_DATA |= OUTNUMBER(0x01); /* Set mode */
       LCDSend();
       u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS * 2;
       u8LCDInternalStatus = LCD_STATUS_WAITING;

   }

   void LCDCR(void) {

       LCDCursor(0x40);

   }

   void LCDPrintNext(void) {
       if (u8HowMany-- > 0) {
           LCD_DATA &= PORTMASK;
           LCD_DATA |= OUTNUMBER(((*u8NextChr)>>0x04));
           LCD_RS = 1;
           LCDSend();
           LCD_DATA &= PORTMASK;
           LCD_DATA |= OUTNUMBER(((*u8NextChr) & 0x0F));
           LCDSend();
           u8NextChr++;
           u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
           u8LCDInternalStatus = LCD_STATUS_PRINTING;
        }
        else {
              u8LCDInternalStatus = LCD_STATUS_READY;
        }
   }

   void LCDPrint(UINT8 *u8Where, UINT8 u8Length) {

       if (u8LCDInternalStatus == LCD_STATUS_READY) {
           if (u8Length > 0) {
               u8HowMany = u8Length;
               u8NextChr = u8Where;
               LCDPrintNext();
           }
           else {    /* Ignore */
           }
       }
       else {
           u8LCDInternalStatus = LCD_STATUS_ERROR;
       }
   }

   void LCDTimeBase(void) {
        if (u8LCDInternalStatus == LCD_STATUS_INIT) {
            LCDInit();
        } else if (u8LCDInternalStatus == LCD_STATUS_PRINTING) {
            LCDPrintNext();
        } else if (u8LCDInternalStatus == LCD_STATUS_WAITING) {
            u8LCDInternalStatus = LCD_STATUS_READY;
        }

    }

    UINT8 LCDStatus(void) {
        return u8LCDInternalStatus;
    }

    void LCDCursor(UINT8 u8DdramAddress) {
        if (u8LCDInternalStatus == LCD_STATUS_READY) {
            u8DdramAddress |= 0x80;
            LCD_DATA &= PORTMASK;
            LCD_DATA |= OUTNUMBER(u8DdramAddress>>4); /* Set mode */
            LCD_RS = 0;
            LCDSend();
            LCD_DATA &= PORTMASK;
            LCD_DATA |= OUTNUMBER(u8DdramAddress & 0x0F);
            LCDSend();
            u8TimerLCD = GTIME_BASE_INTERRUPT_PERMS;
            u8LCDInternalStatus = LCD_STATUS_WAITING;
        }
        else {
            u8LCDInternalStatus = LCD_STATUS_ERROR;
        }
    }

#endif
/* END LCD Driver */
```

6.2.1.2.7 DRIVERSLEDS.c

```
#include "driversLeds.h"

void LedControl(UINT8 u8LedNumber, UINT8 u8NewState);

/* LEDs Driver */

/* Initialize LEDs */
void LedsInit(void) {

   /* Set pins to output and data to one */
   #ifdef LED_ONE
      LED_ONE_DD =    1;
      LED_ONE =       LED_OFF;
   #endif
   #ifdef LED_TWO
      LED_TWO_DD =    1;
      LED_TWO =       LED_OFF;
   #endif
   #ifdef LED_THREE
      LED_THREE_DD =  1;
      LED_THREE =     LED_OFF;
   #endif
   #ifdef LED_FOUR
      LED_FOUR_DD =   1;
      LED_FOUR =      LED_OFF;
   #endif
   #ifdef LED_FIVE
      LED_FIVE_DD =   1;
      LED_FIVE =      LED_OFF;
   #endif
   #ifdef LED_SIX
      LED_SIX_DD =    1;
      LED_SIX =       LED_OFF;
   #endif
   #ifdef LED_SEVEN
      LED_SEVEN_DD =  1;
      LED_SEVEN =     LED_OFF;
   #endif
   #ifdef LED_EIGHT
      LED_EIGHT_DD =  1;
      LED_EIGHT =     LED_OFF;
   #endif

}

/* LED on */
void LedOn(UINT8 u8LedNumber) {
   LedControl(u8LedNumber, LED_ON);
}

/* LED off */
void LedOff(UINT8 u8LedNumber) {
   LedControl(u8LedNumber, LED_OFF);
}

/* LED toogle */
void LedToggle(UINT8 u8LedNumber) {
   switch(u8LedNumber)  {
   #ifdef LED_ONE
      case LD_ONE: {
         LED_ONE = ~ LED_ONE;
         break;
      }
   #endif
   #ifdef LED_TWO
      case LD_TWO: {
         LED_TWO = ~ LED_TWO;
         break;
      }
   #endif
   #ifdef LED_THREE
      case LD_THREE: {
         LED_THREE = ~ LED_THREE;
         break;
      }
   #endif
   #ifdef LED_FOUR
      case LD_FOUR: {
         LED_FOUR = ~ LED_FOUR;
         break;
      }
   #endif
   #ifdef LED_FIVE
      case LD_FIVE: {
         LED_FIVE = ~ LED_FIVE;
         break;
      }
   #endif
   #ifdef LED_SIX
      case LD_SIX: {
         LED_SIX = ~ LED_SIX;
         break;
      }
   #endif
   #ifdef LED_SEVEN
      case LD_SEVEN: {
         LED_SEVEN = ~ LED_SEVEN;
         break;
      }
   #endif
   #ifdef LED_EIGHT
      case LD_EIGHT: {
         LED_EIGHT = ~ LED_EIGHT;
         break;
      }
   #endif
   }
}

/* Intenal LED control */
void LedControl(UINT8 u8LedNumber, UINT8 u8NewState) {
   switch(u8LedNumber)  {
   #ifdef LED_ONE
      case LD_ONE: {
         LED_ONE = u8NewState;
         break;
      }
   #endif
   #ifdef LED_TWO
      case LD_TWO: {
         LED_TWO = u8NewState;
         break;
      }
   #endif
   #ifdef LED_THREE
      case LD_THREE: {
         LED_THREE = u8NewState;
         break;
      }
   #endif
   #ifdef LED_FOUR
      case LD_FOUR: {
         LED_FOUR = u8NewState;
         break;
      }
   #endif
   #ifdef LED_FIVE
      case LD_FIVE: {
         LED_FIVE = u8NewState;
         break;
      }
   #endif
   #ifdef LED_SIX
      case LD_SIX: {
         LED_SIX = u8NewState;
         break;
      }
   #endif
   #ifdef LED_SEVEN
      case LD_SEVEN: {
         LED_SEVEN = u8NewState;
         break;
      }
   #endif
   #ifdef LED_EIGHT
      case LD_EIGHT: {
         LED_EIGHT = u8NewState;
         break;
      }
   #endif
   }
}
/* END LEDs Driver */
```

6.2.1.2.8 DRIVERSRELAY.c

```
#include "driversRelay.h"

/* Relay Driver */

#ifdef RELAY

   /* Initialize RELAY */
   void RelayInit(void) {

      RELAY =    RELAY_OFF;
      /* Set pins to output */
      RELAY_DD = 1;
      /* Set data to 0 (turn off) */
      RELAY =    RELAY_OFF;

   }

   /* RELAY on */
   void RelayOn(void) {
      RELAY = RELAY_ON;
   }

   /* RELAY off */
   void RelayOff(void) {
      RELAY = RELAY_OFF;
   }

   /* RELAY toogle */
   void RelayToggle(void) {
      RELAY = ~ RELAY;
   }

   /* RELAY status */
   UINT8 RelayStatus (void) {
      return RELAY;
   }

#endif
/* END Relay Driver */
```

6.2.1.2.9 DRIVERSSWITCH.c

```
#include "driversSwitch.h"

/* Switch Driver */
#if defined(SWITCH_ONE) || defined(SWITCH_TWO)

   /* Initialize Switch */
   void SwitchInit(void) {

      /* Set pins to input */
      #ifdef SWITCH_ONE
         SWITCH_ONE_DD =  0;
         #ifdef SWITCH_ONE_PE
            SWITCH_ONE_PE = 1;
         #endif
      #endif

      #ifdef SWITCH_TWO
         SWITCH_TWO_DD =  0;
         #ifdef SWITCH_TWO_PE
            SWITCH_TWO_PE = 1;
         #endif
      #endif

   }

   /* Switch status */
   UINT8 SwitchStatus(UINT8 u8SwitchNumber) {
      switch(u8SwitchNumber)    {
         #ifdef SWITCH_ONE
            case SW_ONE: {
               return(SWITCH_ONE);
               break;
            }
         #endif
         #ifdef SWITCH_TWO
            case SW_TWO: {
               return(SWITCH_TWO);
               break;
            }
         #endif
      }
   }

#endif
/* END Switch Driver */
```

6.2.2 HOMEdemoQF4Tx1Tx2

6.2.2.1 Include Files

6.2.2.1.1 TEAMAC.h

```
#ifndef teamac_h
#define teamac_h

void char2Long(unsigned long *pDest,const unsigned char *pSrce);
void Long2char(unsigned char *pDest,unsigned long *pSrce);

#endif
```

6.2.2.1.2 ADC.h

```
#ifndef ADC_h
#define ADC_h

void ADCinit (void);
void interrupt 16 ADC_ISR (void);

#endif
```

6.2.2.1.3 KBI.h

```
#ifndef KBI_h
#define KBI_h

void KBIinit (void);
void interrupt 15 KBI_ISR (void);

#endif
```

6.2.2.1.4 TANGOQF4.h

```
#ifndef MYTANGO_H
#define MYTANGO_H
/******************************************************************************
*
*       Copyright (C) 2004 Motorola, Inc.
*       All Rights Reserved
*
* Filename:     $RCSfile: Tango.h,v $
* Author:       $Author: r29541 $
* Locker:       $Locker: r29541 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:    Tango3 software driver header file for HC908
*
* History:
*
*
* Description:   This is header file for Tango3 software driver for HC908
```

```
*
*
*
* Notes:
*
******************************************************************************/


/*****************************************************************************/
/* This section defines some symbols for use below. DO NOT EDIT!             */
#define TANGO_FSK    1
#define TANGO_OOK   0

#define TANGO_HIGH_BAND   1
#define TANGO_LOW_BAND   0
/*****************************************************************************/



/*****************************************************************************/
/*            THIS SECTION CONTAINS VALUES YOU MUST DEFINE!                  */
/*                                                                           */
#include "MC68HC908QY4.h"               /* Include peripheral declarations   */

#define TANGO_TIMER_ADDRESS     0x20    /* Location of 1st timer register    */
#define TANGO_TIMER_CHANNEL     1       /* Define which timer channel to use */
                                        /* Note:timer channels start from 0  */

#define TANGO_MAX_DATA_SIZE 12          /* Max size of data                  */

                                        /* Set TANGO Mode                    */
#define  TANGO_MODE_VALUE TANGO_OOK     /* TANGO_OOK or TANGO_FSK            */

                                        /* Set timer clock speed in Hz       */
#define TANGO_TIMER_CLOCK_SPEED  1000000

#define TANGO_TIMER_CLOCK_SOURCE    1    /* Use to set clock source for timer */
                                        /* 1 = Bus clock                      */
                                     /* 2 = XCLK- note,not all mcus have XCLK*/
                                        /* 3 = Ext clock                     */

#define TANGO_TIMER_PRESCALE    1       /* Specify timer prescaler value     */
                                         /* NOTE: If using DATACLK from       */
                                         /* Tango ic, prescaler will be forced*/
                                         /* to 1                              */

#define TANGO_TIMER_DISABLE   1 /* Allows driver to turn off timer after use  */
                                /* Delete this #define if you want timer to   */
                               /* stay on                                    */


#define TANGO_CRYSTAL_FREQUENCY  9843700        /* Crystal frequency (in Hz) */
                                                /* Typical values used       */
                                                /* RF Output                 */
                                                /* 315MHz  - 9843700         */
                                                /* 434MHz  - 13560000        */
                                                /* 868MHz  - 13560000        */

                                          /* Set Tango Band                   */
                                          /* TANGO_HIGH_BAND or TANGO_LOW_BAND*/
#define TANGO_BAND_VALUE   TANGO_HIGH_BAND/* High band - 315, 434 MHz         */
                                          /* Low band - 868MHz, 928MHz        */
                                          /* Set Tango data rate in Hz (before*/
#define TANGO_DATA_RATE      2400         /* Manchester encoding)             */


#define TANGO_ENABLE        PTB_PTB1      /* Define pin used for enable     */
                                          /* Defined for Sergio's Board */
#define TANGO_ENABLE_DDR    DDRB_DDRB1    /* If hardwired,delete #defines   */
                                          /* Defined for Sergio's Board */
//#define TANGO_ENABLE          PTB_PTB0  /* Define pin used for enable     */
//#define TANGO_ENABLE_DDR    DDRB_DDRB0  /* If hardwired,delete #defines   */


/****************************************************************************/
/* These may be omitted depending on the hardware setup                     */


#define TANGO_MODE           PTB_PTB0
         /* Define pin used for mode select  *//*Defined for Sergio's Board*/
#define TANGO_MODE_DDR       DDRB_DDRB0
         /* If hardwired,delete #defines     *//*Defined for Sergio's Board*/

#define TANGO_ENABLE_PA          PTB_PTB2
        /*Define pin used for Power amp enable*//*Defined for Sergio's Board*/
#define TANGO_ENABLE_PA_DDR         DDRB_DDRB2
        /*If hardwired, delete #defines       *//*Defined for Sergio's Board*/

/****************************************************************************/

/****************************************************************************/
/* This defines default values for  #defines in the Tango.h , or prints     */
/* errors if missing or incorrect values have been chosen                   */
/*                       DO NOT EDIT THIS SECTION!!                         */

#ifndef TANGO_TIMER_ADDRESS
#error "You must #define symbol TANGO_TIMER_ADDRESS in Tango.H header file"
#endif

#ifndef TANGO_TIMER_CHANNEL
#error "You must #define symbol TANGO_TIMER_CHANNEL in Tango.H header file"
#endif

#ifndef TANGO_MAX_DATA_SIZE
#error "You must #define symbol TANGO_MAX_DATA_SIZE in Tango.H header file"
#endif

#if TANGO_MAX_DATA_SIZE > 127
#error "TANGO_MAX_DATA_SIZE in file Tango.h must be in range 0- 127"
#endif


#ifndef TANGO_MODE_VALUE
#error "You must #define symbol TANGO_MODE_VALUE in Tango.H header file"
#endif

#if TANGO_MODE_VALUE ==TANGO_OOK
        //If OK, do nuthin
#else
    #if TANGO_MODE_VALUE ==TANGO_FSK
        //If OK, do nuthin
    #else
        #error "You must set TANGO_MODE_VALUE to TANGO_OOK or TANGO_FSK in \
                      Tango.H header file"
    #endif
```

```
#endif


#ifndef TANGO_TIMER_CLOCK_SPEED
#error  "You must #define symbol TANGO_TIMER_CLOCK_SPEED in Tango.h header file"
#endif

#ifndef TANGO_TIMER_CLOCK_SOURCE
#error  "You must #define symbol TANGO_TIMER_CLOCK_SOURCE in Tango.h header file"
#endif


#ifndef TANGO_TIMER_PRESCALE
#error "You must #define symbol TANGO_TIMER_PRESCALE in Tango.h header file"
#endif


#ifndef TANGO_CRYSTAL_FREQUENCY
#error "You must #define symbol TANGO_CRYSTAL_FREQUENCY in Tango.h header file"
#endif



#if TANGO_BAND_VALUE ==TANGO_HIGH_BAND
                                            /* If OK, do nothing */
#else
    #if TANGO_BAND_VALUE ==TANGO_LOW_BAND
                                            /* If OK, do nothing */
    #else
        #error "You must set TANGO_BAND_VALUE to TANGO_HIGH or TANGO_LOW in \
                                        Tango.H header file"
    #endif
#endif


#ifndef TANGO_DATA_RATE
#error "You must #define symbol TANGO_DATA_RATE in Tango.h header file"
#endif


/*****************************************************************************/
/*  This section defines various values used in the driver                   */
/*                        DO NOT EDIT THIS SECTION!!                         */


#if TANGO_TIMER_CLOCK_SOURCE == 3
    #define TANGO_TIMER_CLK_IN_CHANNEL  0  /* Timer channel used for clk in  */
                                           /* (usually timer ch 0 on HCS08   */
                                           /* Delete if not using clk input  */
#endif



#ifdef TANGO_TIMER_CLK_IN_CHANNEL       /* If using an external clock source */
    #define TANGO_TIMER_MODULUS  ((TANGO_CRYSTAL_FREQUENCY/64)/TANGO_DATA_RATE)

                            /* If using ext clock,need these to set 2ms delay*/
    #define TANGO_2MS_EXT_H (((TANGO_CRYSTAL_FREQUENCY/500)/256)/64)
    #define TANGO_2MS_EXT_L ((TANGO_CRYSTAL_FREQUENCY/500)/64)


#else                       /* If using internal clock source */
    #define TANGO_TIMER_MODULUS  ((TANGO_TIMER_CLOCK_SPEED/TANGO_DATA_RATE)/ \
                            TANGO_TIMER_PRESCALE)

    #if ( (TANGO_TIMER_CLOCK_SPEED/500)/TANGO_TIMER_MODULUS ) == 0
    #define TANGO_2MS_DELAY 1
    #else
    #define TANGO_2MS_DELAY ((TANGO_TIMER_CLOCK_SPEED/500)/TANGO_TIMER_MODULUS)
    #endif

#endif

#define TANGO_HALF_TIMER_MODULUS   (TANGO_TIMER_MODULUS/2)

#define TANGO_MODH  (TANGO_TIMER_MODULUS/256)
#define TANGO_MODL  (TANGO_TIMER_MODULUS)

#define TANGO_COMH  (TANGO_HALF_TIMER_MODULUS/256)
#define TANGO_COML  (TANGO_HALF_TIMER_MODULUS)






typedef union
{
  unsigned char Byte;
  struct
  {
    unsigned char enabled  :1;    /* 1 = Tango enabled, 0 = Tango disabled    */
    unsigned char enableDelay :1;/* 1 = in 2 ms delay after enabling         */
    unsigned char busy    :1;    /* 1 = currently sending a message, 0= idle */
    unsigned char res1    :1;     /* not used                                 */
    unsigned char eomFlag  :1;     /* 1 = eom required, 0 = no eom required    */
    unsigned char res2    :3;    /* not used                                 */
  }Bits;
}tTANGO_STATUS;


/*    Driver states          */
#define TANGO_DISABLED      0
#define TANGO_READY      1
#define TANGO_IN_ENABLE_DELAY    2
#define TANGO_BUSY        3

/* Internal state machine states */
#define TANGO_ENABLE_DELAY  0
#define TANGO_START      1
#define TANGO_PREAMBLE_1  2
#define TANGO_PREAMBLE_2  3
#define TANGO_SEND_BYTE  4
#define TANGO_EOM_1      5
#define TANGO_EOM_2      6
#define TANGO_END      7
#define TANGO_EXTRA_BIT    8

/*   Constants      */
#define TANGO_OOK_HEADER   0x60    /* Header value = 0110 (4 MSbits)         */
#define TANGO_FSK_HEADER  0x06    /* FSK preamble (4 0's) and Header (0110) */


/* Timer control reg masks */
//#define TANGO_TIMER_ON   (TANGO_TIMER_CLOCK_SOURCE*8)
                                      /* OR this value to timer control */
                                      /* reg to enable clock            */
                                      /* NOTE, cannot be used to switch */
                                      /* from clock to clock            */

#define TANGO_TIMER_OFF    0x20
                         /* OR this value to timer ctrl reg to disable clock */


/* Timer register offsets  */
/* Register address offsets for normal S08 timer */
                                                     /* Tmr status/ctrl reg */
#define TANGO_TIMxTSC     *(unsigned char *)(TANGO_TIMER_ADDRESS+0)
                                                        /* Timer counter H  */
#define TANGO_TIMxTCNTH  *(unsigned char *)(TANGO_TIMER_ADDRESS+1)
                                                        /* Timer counter L  */
#define TANGO_TIMxTCNTL   *(unsigned char *)(TANGO_TIMER_ADDRESS+2)
                                                        /* Timer modulus H  */
#define TANGO_TIMxTMODH *(unsigned char *)(TANGO_TIMER_ADDRESS+3)
                                                        /* Timer modulus L  */
#define TANGO_TIMxTMODL   *(unsigned char *)(TANGO_TIMER_ADDRESS+4)

/* Registers for each timer channel */
#define TANGO_TIMxTSCx  *(unsigned char *)(TANGO_TIMER_ADDRESS+5+ \
                  (3*TANGO_TIMER_CHANNEL)+0)
#define TANGO_TIMxTCHxH  *(unsigned char *)(TANGO_TIMER_ADDRESS+5+ \
                  (3*TANGO_TIMER_CHANNEL)+1)
#define TANGO_TIMxTCHxL  *(unsigned char *)(TANGO_TIMER_ADDRESS+5+ \
                  (3*TANGO_TIMER_CHANNEL)+2)

/* Function prototypes  */
void TangoSendData(void);
void TangoSendPreamble_ID(void);
void TangoSendMessageNoHeader( unsigned char idRepeat);
interrupt void TangoTimerInterrupt(void);
void TangoInitialise(void);
void TangoEnable(void);
void TangoDisable(void);
unsigned char TangoDriverStatus(void);
void TangoCalculateChecksum(void);

#endif //TANGO_H
```

6.2.2.2 Source Code Files

6.2.2.2.1 MAIN.c

```
#include <hidef.h> /* for EnableInterrupts macro */
#include <MC68HC908QY4.h> /* include peripheral declarations */
#include "tangoQF4.h"
#include "teamac.h"
#include "ADC.h"
#include "KBI.h"

#define delta 0x9E3779B9

extern unsigned char tangoTransmitBuffer[TANGO_MAX_DATA_SIZE+2];

unsigned char resultADC=0;
unsigned char InputData=0;
unsigned long TEAMAC_Data[2];
unsigned long TEAMAC_Code;
unsigned char n;
unsigned long key[4];
#pragma CONST_SEG TEAMAC_KEY
const unsigned char TEAMAC_Key[8]={0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08};
#pragma CONST_SEG DEFAULT



void main(void) {

      /* include your code here */

      unsigned int i;
      unsigned char j;
      unsigned char count = 0;    /* Data byte sent in rf message   */
      unsigned char NumberOfRx;


    /* Disable watchdog, enable reset pin, enable debug pin */

      CONFIG2 = 0x00;
      CONFIG1 = 0x01;

      /*Outputs*/
      DDRB_DDRB3 = 1;
      DDRA_DDRA4=  1;
      PTB_PTB3 = 0;
      PTA_PTA4 = 0;

    ADCinit();
    KBIinit();

      NumberOfRx=2;
      EnableInterrupts;

      TangoInitialise(); /*Configures Tango driver using settings from Tango.H*/

    for(j=0;j<NumberOfRx;j++){

        TangoEnable();       /*This enables the Tango ic and starts 2ms delay*/
          /* (Tango ic needs 2ms to stabalise*/
      while(TangoDriverStatus() == TANGO_IN_ENABLE_DELAY){}
                                                /*Wait until end of 2ms delay*/

        tangoTransmitBuffer[0] = ((j+1)<<4);/* Put message Rx1 ID in tx buffer*/
        tangoTransmitBuffer[1] = 7;         /* Put data length in tx buffer */
        tangoTransmitBuffer[2] = 0x00;      /* Set data to 0                */
        tangoTransmitBuffer[3] = 0xFF;      /* Set data to 0                */
        tangoTransmitBuffer[4] = 0x00;      /* Set data to 0                */
        tangoTransmitBuffer[5] = 0x00;
        tangoTransmitBuffer[6] = 0x00;
        tangoTransmitBuffer[7] = 0x00;
        tangoTransmitBuffer[8] = 0x00;
        tangoTransmitBuffer[9] = 0x00;
        /* Send Preamble_ID 10 times    */
        for (i = 0; i <= 10; i++){

            TangoSendPreamble_ID();
            while(TangoDriverStatus() != TANGO_READY ){}
                                     /* Wait until message gone */
```

```
           }

      TangoSendData();                            /* Send data               */
      while(TangoDriverStatus() != TANGO_READY ){}/* Wait until message gone */

      TangoDisable();

        }

    NumberOfRx=1;
    tangoTransmitBuffer[0] = 0x10; /*Default Rx*/

          /* Main loop - goes around this loop for each keypress */
      for (;;){

           /* Wait until a button pressed or a new ADC value*/
           while ( InputData==0 ){

        if(InputData==0){
          while (! ADSCR_COCO )
              ;
          for (i = 0; i< 0x7ff; i++){
              if(InputData !=0)
                break;
              }

          if(resultADC != ADR)
            if(resultADC < (ADR-1) || resultADC > (ADR+1)){
              resultADC=ADR;
              InputData=3;
              }
          }

        if (PTA_PTA0==0 && PTA_PTA3==0)
            InputData=4;
             }

            switch (InputData){

               case  1:{
                   for (i = 0; i< 0xfff; i++) {}
                   if (PTA_PTA0==0)
                     if(PTA_PTA3==0){
                       tangoTransmitBuffer[3] = 0xFF;
                InputData=4;
                break;
                }

                     PTB_PTB3 = 1;
                    tangoTransmitBuffer[2] = ++count;
                                /* Put data byte in tx buffer */
                      tangoTransmitBuffer[3] = 0x00;
                      tangoTransmitBuffer[4] = resultADC;

                     break;
                     }


               case  2:{
                  for (i = 0; i< 0xfff; i++) {}
                  if (PTA_PTA0==0)
                     if(PTA_PTA3==0){
                InputData=4;
                tangoTransmitBuffer[3] = 0xFF;
                break;
                }

                    PTB_PTB3 = 1;
                    tangoTransmitBuffer[2] = ++count;
                                    /* Put data byte in tx buffer  */
                    tangoTransmitBuffer[3] = 0x01;
                    tangoTransmitBuffer[4] = resultADC;

                    break;
                }
                case  3:{
                    PTA_PTA4 = 1;
                    tangoTransmitBuffer[2] = ++count;
                                    /* Put data byte in tx buffer  */
                    tangoTransmitBuffer[3] = 0x02;
                    tangoTransmitBuffer[4] = resultADC;

                    break;
                    }


          case  4:{
            InputData=0;
            /*Turn On leds Indicating select Rx mode*/
            PTA_PTA4 = 1;
            PTB_PTB3 = 1;
            /*waiting for user to press any push button*/
            for (j = 0; j< 3; j++)
              for (i = 0; i< 0x7fff; i++) {}

            if(InputData == 1){
              /* Put message ID in tx buffer  */
              tangoTransmitBuffer[0] = 0x10;
              NumberOfRx=1;
              PTB_PTB3 = 0;
              for (j = 0; j< 10; j++){
                PTA_PTA4 =~PTA_PTA4;
                for (i = 0; i< 0xfff; i++) {}
                }

            }else if(InputData == 2){
                /* Put message ID in tx buffer  */
                tangoTransmitBuffer[0] = 0x20;
                NumberOfRx=1;
                PTA_PTA4 = 0;
                for (j = 0; j< 10; j++){

                  PTB_PTB3 =~PTB_PTB3;
                  for (i = 0; i< 0xfff; i++) {}
                  }
                }else{

                  NumberOfRx=2;
                  for (j = 0; j< 10; j++)
                    {

                    PTB_PTB3 =~PTB_PTB3;
                    PTA_PTA4 =~PTA_PTA4;
                    for (i = 0; i< 0xfff; i++) {}
                    }
                 }
            PTA_PTA4 =0;
            PTB_PTB3 =0;
            break;
            }

                default:{break;}
                }

      InputData=0;

      /********* START OF TEAMAC CODE  *****/
      TEAMAC_Data[0]=(unsigned long)tangoTransmitBuffer[2];
      TEAMAC_Data[1]=(unsigned long)tangoTransmitBuffer[3];

      char2Long(key,   &TEAMAC_Key[0]);
      char2Long(key+1, &TEAMAC_Key[1]);
      char2Long(key+2, &TEAMAC_Key[2]);
      char2Long(key+3, &TEAMAC_Key[4]);

      TEAMAC_Code = 0;
      n = 32;

      while(n-- > 0){
        TEAMAC_Data[0] += (((TEAMAC_Data[1] << 4) ^ (TEAMAC_Data[1] >> 5)) +
                        TEAMAC_Data[1]) ^ (TEAMAC_Code + key[TEAMAC_Code&3]);
        TEAMAC_Code += delta;
        TEAMAC_Data[1] += (((TEAMAC_Data[0] << 4) ^ (TEAMAC_Data[0] >> 5)) +
                TEAMAC_Data[0]) ^ (TEAMAC_Code + key[(TEAMAC_Code>>11) & 3]);
        }

      TEAMAC_Code = TEAMAC_Data[0] ^ TEAMAC_Data[1];;
      Long2char(&tangoTransmitBuffer[5],&TEAMAC_Code);
      /****** END OF TEAMAC CODE ******/

      for(j=0;j<NumberOfRx;j++){

        if(NumberOfRx==2)
          tangoTransmitBuffer[0] = ((j+1)<<4);

        TangoEnable(); /* This enables the Tango ic and starts 2ms delay    */
                         /* (Tango ic needs 2ms to stabalise)               */

         while(TangoDriverStatus() == TANGO_IN_ENABLE_DELAY){}
                       /* Wait until end of 2ms delay */

         /* Send Preamble_ID 10 times */
           for ( i = 0; i <= 10; i++){

               TangoSendPreamble_ID();
               while(TangoDriverStatus() != TANGO_READY ){}
                       /* Wait until message gone   */

             }

           TangoSendData(); /* Send Data */
           while(TangoDriverStatus() != TANGO_READY ){}
                       /* Wait until message gone   */

           TangoDisable();
        }

     PTB_PTB3 = 0;
     PTA_PTA4 = 0;
```

```
    }/*LOOP FOREVER*/

}/*END OF MAIN*/
```

6.2.2.2.2 ADC.c

```
#include <MC68HC908QY4.h>
#include "ADC.h"

extern unsigned char resultADC;
extern unsigned char InputData;

void ADCinit (void) {
  DDRA_DDRA5=0;   //Enable PTA5 as input
  ADICLK=0x80;  //ADC operates with BusCLK / 16
  ADSCR=0x23;    //Enable ADC with continous conversion & interrupts
}

void interrupt 16 ADC_ISR (void) {
  resultADC=ADR;
  InputData =3;
  ADSCR_AIEN=0;
}
```

6.2.2.2.3 KBI.c

```
#include <MC68HC908QY4.h>
#include "KBI.h"

extern unsigned char InputData;


void KBIinit (void) {

DDRA_DDRA0=0;
DDRA_DDRA3=0;

KBSCR_IMASKK= 1; //mask interrupts
KBIER_KBIE0 = 1; //Enables pin0 of KBI
KBIER_KBIE3 = 1; //Enables pin3 of KBI
KBSCR_ACKK  = 1; //Clear interrupt acknowledge
KBSCR_IMASKK= 0; //unmask interrupts


KBSCR = 0x00;  //CONFIGURES KBI STATUS & CTRL REG
      //IMASK=0; clear any false interrupt
      //Modek=0; interrupt request on falling edge

}

void interrupt 15 KBI_ISR (void) {

  KBSCR|=0x04;  //Acknoledge KB interrrupt

  if (PTA_PTA0==0)
    if (PTA_PTA3==1)
```

```
      InputData=1;

  if (PTA_PTA3==0)
    if (PTA_PTA0==1)
      InputData=2;

}
```

6.2.2.2.4 TEAMAC.c

```
#include "teamac.h"

extern unsigned long TEAMAC_Data[2];
extern unsigned long TEAMAC_Code;
extern unsigned char TEAMAC_Key[8];

void char2Long(unsigned long *pDest,const unsigned char *pSrce)
{
  unsigned char bytes = 4;
  *pDest = 0;
  while (bytes--)
    {
    *pDest <<= 8;
    *pDest |= (*pSrce & 0xFF);
    *pSrce++;
    }
}


void Long2char(unsigned char *pDest,unsigned long *pSrce)
{
  unsigned char i;
  pDest+=3;
  for(i=0;i<4;i++)
  {
    *pDest = (unsigned char)(((*pSrce)>>(8*i)) & 0x000000FF);
    pDest--;

  }

}
```

6.2.2.2.5 TANGOQF4.c

```
/******************************************************************************
*
*       Copyright (C) 2004 Motorola, Inc.
*       All Rights Reserved
*
* Filename:     $RCSfile: Tango.c,v $
* Author:       $Author: r29541 $
* Locker:       $Locker: r29541 $
* State:        $State: Exp $
* Revision:     $Revision: 1.0 $
*
* Functions:    Tango3 software driver for HC908
*
```

```
* History:
*
*
* Description:   This is C code for Tango3 software driver for HC908
*
*
*
* Notes:
*
*****************************************************************************/


#include "tangoQF4.h"          /* Include driver header file                 */




unsigned char tangoDriverState;


unsigned char bitCounter;           /* bits in current byte remaining        */
unsigned char byteCounter;      /* number of bytes remaining to send         */
unsigned char data;      /* local data store (so that message buffer contents */
                        /* not corrupted)                                    */
unsigned char enableDelayCounter;
                            /* Counter used for 2 ms delay when part enabled */

unsigned char * ptrData; /* pointer used to retrieve data from message buffer*/

tTANGO_STATUS status;     /* contains status flags                            */

unsigned char tangoTransmitBuffer[TANGO_MAX_DATA_SIZE+2];
                         /*  Data buffer for holding message
                             Format of buffer is :-

                             ID byte
                             Data Length Byte - note this length excludes
                                                the ID byte !!
                             Data MSB
                             ...
                             ...
                             Data LSB

                             Format of control/length byte

                             Bits 7-4, not used
                             Bits 3-0, message length
                         */

/* Send preamble, header, then data, then EOM */
void TangoSendData(void)
{
  volatile unsigned char temp;


    status.Bits.eomFlag = 1;
    status.Bits.busy = 1;

    TangoCalculateChecksum();         /* Add checksum to message             */
    ptrData = &tangoTransmitBuffer[1];/* Point to 1st databyte in msg buffer*/
    byteCounter = tangoTransmitBuffer[1]+3;/* Add 1 byte for header transfer,
                                              1 for length, 1 for checksum  */
    #if TANGO_MODE_VALUE == TANGO_FSK    /*  If FSK modulation               */
    //{
      data = TANGO_FSK_HEADER;      /* Schedule 4bit preamble + 4bit header */
      bitCounter = 8;
      tangoDriverState = TANGO_SEND_BYTE;
      TANGO_TIMxTCHxH = TANGO_COMH;
      TANGO_TIMxTCHxL  = TANGO_COML;/* Set O/C to 1/2 modulus               */
      TANGO_TIMxTSCx = 0x58;        /* O/C, clear on compare                */
    //}
    #else                            /* else if OOK modulation               */
    //{
      data = TANGO_OOK_HEADER;      /* First byte to be sent will be header */
      bitCounter = 4;                  /* Header uses 4 bits                   */
      tangoDriverState = TANGO_START;
      TANGO_TIMxTCHxH = TANGO_MODH;
      TANGO_TIMxTCHxL = TANGO_MODL;  /* Set O/C to = modulus                 */
      temp = TANGO_TIMxTSCx;
      TANGO_TIMxTSCx = 0x18;        /* O/C clear on compare                 */
                                    /* (clears pending interrupt)           */
      TANGO_TIMxTSCx = 0x5c;        /* O/C, set on compare                  */
    //}
    #endif // TANGO_MODE = TANGO_FSK

  #if TANGO_TIMER_CLOCK_SOURCE==1    /* Start timer                          */
    TANGO_TIMxTSC = TANGO_TIMxTSC & 0xdf; /* (if not already running)       */
  #else
    #if TANGO_TIMER_CLOCK_SOURCE==2
      #error "XTAL clock not valid as a source clock for TANGO_TIMER_CLOCK_SOURCE"
    #else
       #if TANGO_TIMER_CLOCK_SOURCE==3
         TANGO_TIMxTSC = TANGO_TIMxTSC |  0x07;
       #endif
     #endif
  #endif

        asm cli;                     /* Enable Interrupts                    */
}


/* Send preamble , then ID)  */
void TangoSendPreamble_ID(void)
{
volatile unsigned char temp;
       status.Bits.eomFlag = 0;
       status.Bits.busy = 1;

    #if TANGO_MODE_VALUE == TANGO_FSK  /* If  FSK modulation                  */
    //{
      ptrData = &tangoTransmitBuffer[0];/* Point to ID byte in message buffer*/
      byteCounter = 2;            /* One byte for preamble, 1 for ID,     */
      bitCounter= 4;              /* Preamble uses 4 bits                 */
      data = 0;                    /* Preload data with preamble (4 zeroes)*/
      tangoDriverState = TANGO_SEND_BYTE;
      TANGO_TIMxTCHxH = TANGO_COMH;
      TANGO_TIMxTCHxL = TANGO_COML;  /* Set O/C to 1/2 modulus                */
      TANGO_TIMxTSCx  = 0x58;        /* O/C, clear on compare                 */
    //}
    #else                            /* else if OOK modulation                */
    //{
      data = tangoTransmitBuffer[0];    /* Copy ID to global variable        */
      byteCounter = 1;
      bitCounter = 8;
      tangoDriverState = TANGO_START;
      TANGO_TIMxTCHxH = TANGO_MODH;
      TANGO_TIMxTCHxL = TANGO_MODL;    /* Set O/C to = modulus                 */
      temp = TANGO_TIMxTSCx;
      TANGO_TIMxTSCx = 0x18;        /* O/C clear on compare                  */
                                    /* (clears pending interrupt)            */
      TANGO_TIMxTSCx = 0x5c;        /* O/C, set on compare                   */
      //}
    #endif

  #if TANGO_TIMER_CLOCK_SOURCE==1      /* Start timer                  */
    TANGO_TIMxTSC = TANGO_TIMxTSC & 0xdf;     /* (if not already running)      */
  #else
    #if TANGO_TIMER_CLOCK_SOURCE==2
      #error "XTAL clock not valid as a source clock for TANGO_TIMER_CLOCK_SOURCE"
    #else
       #if TANGO_TIMER_CLOCK_SOURCE==3
         TANGO_TIMxTSC = TANGO_TIMxTSC |  0x07;
       #endif
     #endif
  #endif

        asm cli;
}


/* Send message with no header         */
/* Format: Preamble,  ID (x idRepeat), data, EOM  */
void TangoSendMessageNoHeader( unsigned char idRepeat)
{
volatile unsigned char temp;

  status.Bits.eomFlag = 1;
  status.Bits.busy = 1;
  TangoCalculateChecksum();             /* Add checksum to message            */
  ptrData = &tangoTransmitBuffer[0];   /* Point to ID byte in message buffer */
  #if TANGO_MODE_VALUE == TANGO_FSK     /* If FSK modulation                  */
  //{
    data = TANGO_FSK_HEADER;
    bitCounter = 4;                               /*  4 bits for preamble     */
    byteCounter = tangoTransmitBuffer[1] + idRepeat+4;/*Add number of ID repeats*/
                                                 /* +4 for ID, preamble,     */
                                                 /* length byte, checksum    */
    tangoDriverState = TANGO_SEND_BYTE;
    TANGO_TIMxTCHxH = TANGO_COMH;
    TANGO_TIMxTCHxL = TANGO_COML;                 /* Set O/C to 1/2 modulus   */
    TANGO_TIMxTSCx = 0x58;                       /* O/C, clear on compare    */
  //}
  #else                                           /* else if OOK modulation   */
  //{
    data = *ptrData++;                           /* First byte to be sent    */
                                                 /* will be ID               */
    bitCounter = 8;                               /* ID byte uses 8 bits      */
    byteCounter = tangoTransmitBuffer[1] + idRepeat+3;/*Add number of ID repeats*/
                                                 /* +3 for ID, length byte,  */
                                                 /* checksum                 */
    tangoDriverState = TANGO_START;
    TANGO_TIMxTCHxH = TANGO_MODH;
    TANGO_TIMxTCHxL = TANGO_MODL;                 /* Set O/C to = modulus     */
    temp = TANGO_TIMxTSCx;
    TANGO_TIMxTSCx = 0x18;                       /* O/C clear on compare     */
                                                 /* clears pending interrupt)*/
    TANGO_TIMxTSCx = 0x5c;                       /* O/C, set on compare      */
  //}
  #endif

  #if TANGO_TIMER_CLOCK_SOURCE==1      /* Start timer                  */
    TANGO_TIMxTSC = TANGO_TIMxTSC & 0xdf;         /* (if not already running) */
  #else
    #if TANGO_TIMER_CLOCK_SOURCE==2
      #error "XTAL clock not valid as a source clock for TANGO_TIMER_CLOCK_SOURCE"
    #else
       #if TANGO_TIMER_CLOCK_SOURCE==3
         TANGO_TIMxTSC = TANGO_TIMxTSC |  0x07;
       #endif
     #endif
  #endif

  asm cli;
}


interrupt void TangoTimerInterrupt(void)
{
volatile unsigned char temp;

  temp = TANGO_TIMxTSCx;                          /* Read ch1 flag           */

  switch (tangoDriverState)
  {


    case TANGO_ENABLE_DELAY:

            if (--enableDelayCounter == 0)
            {
            status.Bits.enableDelay = 0;
                        TANGO_TIMxTSCx = 0x18;   /* Disable channel int, */
                                                 /* o/c clear            */
                        #ifdef TANGO_TIMER_CLK_IN_CHANNEL/*If using ext clock*/
                            TANGO_TIMxTMODH = TANGO_MODH;/*Load modulus with bit*/
                                                         /*timing values      */
                           TANGO_TIMxTMODL = TANGO_MODL;
                        #endif
                        break;
            }
            else
            {
              TANGO_TIMxTSCx = 0x58;        /* O/C clear            */
                break;
            }
    case TANGO_START:
            TANGO_TIMxTCHxH = TANGO_COMH;
            TANGO_TIMxTCHxL = TANGO_COML;    /* Set O/C to 1/2 modulus   */
            tangoDriverState = TANGO_PREAMBLE_1;
            TANGO_TIMxTSCx = 0x5c;        /* Clears int flag          */
            break;
    case TANGO_PREAMBLE_1:
            tangoDriverState = TANGO_PREAMBLE_2;
            TANGO_TIMxTSCx = 0x5c;        /* Clears int flag */
            break;
    case TANGO_PREAMBLE_2:
            tangoDriverState = TANGO_SEND_BYTE;
            TANGO_TIMxTSCx = 0x5e;            /* PWM , low true pulses    */
                                                /*( _|-  Manchester output )*/
            break;
```

```
case TANGO_SEND_BYTE:
        if (bitCounter == 0)
        {
          byteCounter--;
          if (byteCounter == 0)      /* If last byte, then add   */
                                          /* extra bit                */
          {
            tangoDriverState = TANGO_EXTRA_BIT;
            TANGO_TIMxTSCx = 0x5e;    /* PWM , low true pulses    */
                                        /*( _|-  Manchester output )*/
            break;
          }
          else                /* byteCounter != 0         */
          {
           #if TANGO_MODE_VALUE == TANGO_FSK
              if (byteCounter > tangoTransmitBuffer[1]+3) /*If ID repeat*/
           #else
            if (byteCounter > tangoTransmitBuffer[1]+2)  /*If ID repeat*/
          #endif
            {
              data = tangoTransmitBuffer[0];   /* Data = ID       */
            }
            else
            {
              data = *ptrData++;    /* Get next byte to send    */
            }
            bitCounter = 8;
          }
        }
                          /* if bitCounter != 0           */
        if  ( (data & 0x80) == 0)    /* if MSB = 0                  */
        {
          TANGO_TIMxTSCx = 0x5e;    /* PWM , low true pulses        */
                                      /* ( _|-  Manchester output )   */
        }
        else              /* if MSB = 1                   */
        {
          TANGO_TIMxTSCx = 0x5a;    /* PWM, high true pulses        */
                                      /* (-|_  Manchester output)     */
        }
        bitCounter--;
        data = data << 1;        /* Shift data by 1 bit          */
        break;


case  TANGO_EXTRA_BIT:
        if (status.Bits.eomFlag == 1)  /* if require eom               */
        {
          tangoDriverState = TANGO_EOM_1;
        }
        else
        {
          tangoDriverState = TANGO_END;
        }
        TANGO_TIMxTSCx = 0x58;      /* O/C ,clear on match          */
        TANGO_TIMxTCHxH = TANGO_MODH;
        TANGO_TIMxTCHxL = TANGO_MODL;  /* Set compare to == modulus    */
        break;
case   TANGO_EOM_1:
        tangoDriverState = TANGO_EOM_2;
        TANGO_TIMxTSCx = 0x58;              /* O/C , clear on match */
        break;
case   TANGO_EOM_2:
```

```
            tangoDriverState = TANGO_END;
            TANGO_TIMxTSCx = 0x58;              /* O/C , clear on match */
            break;
    case   TANGO_END:
            status.Bits.eomFlag = 0;
            status.Bits.busy = 0;
                      TANGO_TIMxTSCx = 0x18;/* Disable channel int, o/c clear*/
            #if TANGO_TIMER_DISABLE == 1
              TANGO_TIMxTSC = TANGO_TIMxTSC | TANGO_TIMER_OFF;/*Turn off timer*/
                                                           /* if required  */
            #endif
    default:    break;


  }
}


/* Initialise the timer channel and tango     */
/* Note Tango is not power on by this function  */
/* Use TangoEnable to power up Tango            */

void TangoInitialise(void)
{
/* Setup Tango */
#ifdef TANGO_MODE
  #if TANGO_MODE_VALUE == TANGO_OOK
     TANGO_MODE = 0;
  #else
     TANGO_MODE = 1;
  #endif

  TANGO_MODE_DDR = 1;
#endif

#ifdef TANGO_BAND
  TANGO_BAND = TANGO_BAND_VALUE;
  TANGO_BAND_DDR = 1;
#endif

#ifdef TANGO_ENABLE
  TANGO_ENABLE = 0;
  TANGO_ENABLE_DDR = 1;                        /* Tango is not enabled     */
#endif

#ifdef TANGO_ENABLE_PA
    TANGO_ENABLE_PA_DDR = 1;
    TANGO_ENABLE_PA = 0;
#endif

  status.Byte = 0;                             /* Reset flags              */

#ifdef TANGO_TIMER_CLK_IN_CHANNEL              /* If using external clock  */
    TANGO_TIMxTMODH  = TANGO_2MS_EXT_H;/* Load modulus with 2ms timeout value*/
    TANGO_TIMxTMODL  = TANGO_2MS_EXT_L;
#else                                  /* If using internal clock            */
  TANGO_TIMxTMODH = TANGO_MODH;        /* Load modulus with bit timing values*/
  TANGO_TIMxTMODL = TANGO_MODL;
#endif
}


/* Powers up Tango and schedules 2 ms startup delay */
```

```
void TangoEnable(void)
{
#ifdef TANGO_ENABLE
    TANGO_ENABLE = 1;
#endif

#ifdef TANGO_ENABLE_PA
        TANGO_ENABLE_PA = 1;            /* BUG !! missing semicolon */
#endif
       status.Bits.enabled = 1;
    status.Bits.enableDelay = 1;

        #ifdef TANGO_TIMER_CLK_IN_CHANNEL           /* If using ext clock    */
            enableDelayCounter = 1;
            TANGO_TIMxTCHxH = TANGO_2MS_EXT_H;
            TANGO_TIMxTCHxL = TANGO_2MS_EXT_L;       /* Set for 2 ms delay   */
        #else                                       /* If using int clock    */
            enableDelayCounter = TANGO_2MS_DELAY;
        TANGO_TIMxTCHxH = TANGO_MODH;
        TANGO_TIMxTCHxL = TANGO_MODL;          /* Set O/C to = modulus        */
        #endif

        #ifdef TANGO_TIMER_CLK_IN_CHANNEL        /* If using external clock  */
            TANGO_TIMxTMODH = TANGO_2MS_EXT_H;   /* Load modulus with 2ms
                                                               timeout value */
            TANGO_TIMxTMODL = TANGO_2MS_EXT_L;
        #else                                    /* If using internal clock  */
          TANGO_TIMxTMODH = TANGO_MODH;          /* Load modulus with bit
                                                               timing values */
          TANGO_TIMxTMODL = TANGO_MODL;
        #endif

    TANGO_TIMxTSCx = 0x18;                        /* O/C clear on compare    */
                                                /* clears pending interrupt) */
    TANGO_TIMxTSCx = 0x58;                  /* O/C , clear on match          */
    tangoDriverState = TANGO_ENABLE_DELAY;

  #if TANGO_TIMER_CLOCK_SOURCE==1            /* Start timer                   */
    TANGO_TIMxTSC = TANGO_TIMxTSC & 0xdf;        /* (if not already running)  */
  #else
    #if TANGO_TIMER_CLOCK_SOURCE==2
      #error "XTAL clock not valid as a source clock for TANGO_TIMER_CLOCK_SOURCE"
    #else
       #if TANGO_TIMER_CLOCK_SOURCE==3
         TANGO_TIMxTSC = TANGO_TIMxTSC |  0x07;
       #endif
     #endif
  #endif

       asm cli
}



/* Disables Tango */
void TangoDisable(void)
{

#ifdef TANGO_ENABLE
    TANGO_ENABLE = 0;
#endif
       status.Bits.enabled = 0;
     TANGO_TIMxTSCx = 0x18;             /* Disable channel int, o/c clear   */
```

```
#if  TANGO_TIMER_DISABLE  == 1
    TANGO_TIMxTSC = TANGO_TIMxTSC | TANGO_TIMER_OFF;
                                              /* Turn off timer if required */
#endif
}



/* Return current status of the driver  */
/* TANGO_DISABLED   disabled */
/* TANGO_IN_ENABLE_DELAY  - waiting for 2ms delay */
/* TANGO_READY  */
/* TANGO_BUSY - sending message */

unsigned char TangoDriverStatus(void)
{
  if (0 == status.Bits.enabled)           /* If tango disabled            */
    return TANGO_DISABLED;
  else if (1 == status.Bits.enableDelay) /* If in 2ms delay              */
    return TANGO_IN_ENABLE_DELAY;
  else if (0 == status.Bits.busy)         /* else if not busy             */
    return TANGO_READY;
  else
      return TANGO_BUSY;
}


/* Append a checksum on to message */
void TangoCalculateChecksum(void)
{
  unsigned char temp;
    asm
    {
      PSHA
   PSHX
        LDA *( @tangoTransmitBuffer +1)
        ADD #$02        ;Add ID, length
        STA temp
        CLRA

        CLC
        LDHX  @tangoTransmitBuffer
     loop:        ;Calculate checksum
        ADC    ,X
        AIX    #$01
        DEC    temp
        BNE   loop
        ADC    #0    ; Add final carry
        COMA
        STA     ,X    ;Append on to message
        PULX
        PULA

    }
}
```

6.2.2.2.6 START08.c

```
/******************************************************************************
  FILE        : start08.c
  PURPOSE     : 68HC08 standard startup code
  LANGUAGE    : ANSI-C / INLINE ASSEMBLER
  ----------------------------------------------------------------------------
  HISTORY
    22 oct 93         Created.
    04/17/97          Also C++ constructors called in Init().
 ******************************************************************************/

#include <start08.h>

/**********************************************************************/
#pragma DATA_SEG FAR _STARTUP
struct _tagStartup _startupData;    /* read-only:
                                     _startupData is allocated in ROM and
                                     initialized by the linker */


#define USE_C_IMPL 0 /* for now, we are using the inline assembler implementation for the
startup code */

#if !USE_C_IMPL
#pragma MESSAGE DISABLE C20001 /* Warning C20001: Different value of stackpointer depending on
control-flow */
/* the function _COPY_L releases some bytes from the stack internally */

#ifdef __OPTIMIZE_FOR_SIZE__
#pragma NO_ENTRY
#pragma NO_EXIT
#pragma NO_FRAME
/*lint -esym(528, loadByte) inhibit warning about not referenced loadByte function */
static void near loadByte(void) {
  asm {
             PSHH
             PSHX
#ifdef __HCS08__
             LDHX    5,SP
             LDA     0,X
             AIX     #1
             STHX    5,SP
#else
             LDA     5,SP
             PSHA
             LDX     7,SP
             PULH
             LDA     0,X
             AIX     #1
             STX     6,SP
             PSHH
             PULX
             STX     5,SP
#endif
             PULX
             PULH
             RTS
  }
}
#endif /* __OPTIMIZE_FOR_SIZE__ */
```

```
#endif

/*lint -esym(752,_COPY_L)  inhibit message on dunction declared, but not used (it is used in
HLI) */
extern void _COPY_L(void);
/* DESC:    copy very large structures (>= 256 bytes) in 16 bit address space (stack incl.)
   IN:      TOS count, TOS(2) @dest, H:X @src
   OUT:
   WRITTEN: X,H */
#ifdef __ELF_OBJECT_FILE_FORMAT__
  #define toCopyDownBegOffs 0
#else
  #define toCopyDownBegOffs 2 /* for the hiware format, the toCopyDownBeg field is a long.
Because the HC08 is big endian, we have to use an offset of 2 */
#endif
static void Init(void) {
/* purpose:     1) zero out RAM-areas where data is allocated
                2) init run-time data
                3) copy initialization data from ROM to RAM
 */
  /*lint -esym(529,p,i)  inhibit warning about symbols not used: it is used in HLI below */
  int i;
  int *far p;
  /*lint +e529 */
#if USE_C_IMPL   /* C implementation of ZERO OUT and COPY Down */
  int j;
  char *dst;
  _Range *far r;

  r = _startupData.pZeroOut;

  /* zero out */
  for (i=0; i != _startupData.nofZeroOuts; i++) {
    dst = r->beg;
    j = r->size;
    do {
      *dst = 0; /* zero out */
      dst++;
      j--;
    } while(j != 0);
    r++;
  }
#else /* faster and smaller asm implementation for ZERO OUT */
  asm {
ZeroOut:     ;
             LDA    _startupData.nofZeroOuts:1 ; nofZeroOuts
             INCA
             STA    i:1                        ; i is counter for number of zero outs
             LDA    _startupData.nofZeroOuts:0 ; nofZeroOuts
             INCA
             STA    i:0
             LDHX   _startupData.pZeroOut      ; *pZeroOut
             BRA    Zero_5
Zero_3:    ;
            ; CLR    i:1 is already 0
Zero_4:    ;
             ; { HX == _pZeroOut }
             PSHX
             PSHH
             ; { nof bytes in (int)2,X }
             ; { address in (int)0,X   }
             LDA    0,X
             PSHA
             LDA    2,X
             INCA
             STA    p                  ; p:0 is used for high byte of byte counter
             LDA    3,X
             LDX    1,X
             PULH
             INCA
             BRA    Zero_0
Zero_1:     ;
            ;  CLRA   A is already 0, so we do not have to clear it
Zero_2:     ;
             CLR    0,X
             AIX    #1
Zero_0:     ;
             DBNZA  Zero_2
Zero_6:
             DBNZ   p, Zero_1
             PULH
             PULX                           ; restore *pZeroOut
             AIX    #4                      ; advance *pZeroOut
Zero_5:     ;
             DBNZ   i:1, Zero_4
             DBNZ   i:0, Zero_3
             ;
CopyDown:    ;

  }

#endif

  /* copy down */
  /* _startupData.toCopyDownBeg  --->  {nof(16) dstAddr(16) {bytes(8)}^nof} Zero(16) */
#if USE_C_IMPL /* (optimized) C implementation of COPY DOWN */
  p = (int*far)_startupData.toCopyDownBeg;
  for (;;) {
    i = *p; /* nof */
    if (i == 0) {
      break;
    }
    dst = (char*far)p[1]; /* dstAddr */
    p+=2;
    do {
      /* p points now into 'bytes' */
      *dst = *((char*far)p); /* copy byte-wise */
      ((char*far)p)++;
      dst++;
      i--;
    } while (i!= 0);
  }
#elif defined(__OPTIMIZE_FOR_SIZE__)
  asm {
#ifdef __HCS08__
             LDHX   _startupData.toCopyDownBeg:toCopyDownBegOffs
             PSHX
             PSHH
#else
             LDA    _startupData.toCopyDownBeg:(1+toCopyDownBegOffs)
             PSHA
             LDA    _startupData.toCopyDownBeg:(0+toCopyDownBegOffs)
             PSHA
#endif
Loop0:
             JSR    loadByte  ; load high byte counter
             TAX              ; save for compare
             INCA
             STA    i
             JSR    loadByte  ; load low byte counter
             INCA
             STA    i:1
             DECA
             BNE    notfinished
             CBEQX  #0, finished
notfinished:

             JSR    loadByte  ; load high byte ptr
             PSHA
             PULH
             JSR    loadByte  ; load low byte ptr
             TAX              ; HX is now destination pointer
             BRA    Loop1
Loop3:
Loop2:
             JSR    loadByte  ; load data byte
             STA    0,X
             AIX    #1
Loop1:
             DBNZ   i:1, Loop2
             DBNZ   i:0, Loop3
             BRA    Loop0

finished:
             AIS #2
    };
#else /* optimized asm version. Some bytes (ca 3) larger than C version (when considering the
runtime routine too), but about 4 times faster */
  asm {
#ifdef __HCS08__
             LDHX   _startupData.toCopyDownBeg:toCopyDownBegOffs
#else
             LDX    _startupData.toCopyDownBeg:(0+toCopyDownBegOffs)
             PSHX
             PULH
             LDX    _startupData.toCopyDownBeg:(1+toCopyDownBegOffs)
#endif
next:
             LDA   0,X    ; list is terminated by 2 zero bytes
             ORA   1,X
             BEQ copydone
             PSHX         ; store current position
             PSHH
             LDA   3,X    ; psh dest low
             PSHA
             LDA   2,X    ; psh dest high
             PSHA
             LDA   1,X    ; psh cnt low
             PSHA
             LDA   0,X    ; psh cnt high
             PSHA
             AIX   #4
             JSR  _COPY_L ; copy one block
             PULH
             PULX
             TXA
             ADD   1,X    ; add low
             PSHA
             PSHH
             PULA
             ADC   0,X    ; add high
             PSHA
             PULH
             PULX
             AIX   #4
             BRA next
copydone:
  };
#endif


  /* FuncInits: for C++, this are the global constructors */
#ifdef __cplusplus
#ifdef __ELF_OBJECT_FILE_FORMAT__
  i = (int)(_startupData.nofInitBodies - 1);
  while ( i >= 0) {
    (&_startupData.initBodies->initFunc)[i]();  /* call C++ constructors */
    i--;
  }
#else
  if (_startupData.mInits != NULL) {
    _PFunc *fktPtr;
    fktPtr = _startupData.mInits;
    while(*fktPtr != NULL) {
      (**fktPtr)(); /* call constructor */
      fktPtr++;
    }
  }
#endif
#endif
  /* LibInits: used only for ROM libraries */
}

#pragma NO_EXIT
#ifdef __cplusplus
  extern "C"
#endif
void _Startup (void) { /* To set in the linker parameter file: 'VECTOR 0 _Startup' */
/*  purpose:    1)  initialize the stack
                2)  initialize run-time, ...
                    initialize the RAM, copy down init dat etc (Init)
                3)  call main;
    called from: _PRESTART-code generated by the Linker
*/
#ifdef __ELF_OBJECT_FILE_FORMAT__
  DisableInterrupts;  /* in HIWARE format, this is done in the prestart code */
#endif
  for (;;) { /* forever: initialize the program; call the root-procedure */
    if (!(_startupData.flags&STARTUP_FLAGS_NOT_INIT_SP)) {
      /* initialize the stack pointer */
      INIT_SP_FROM_STARTUP_DESC();
    }
    Init();
    (*_startupData.main)();
  } /* end loop forever */
}
```

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